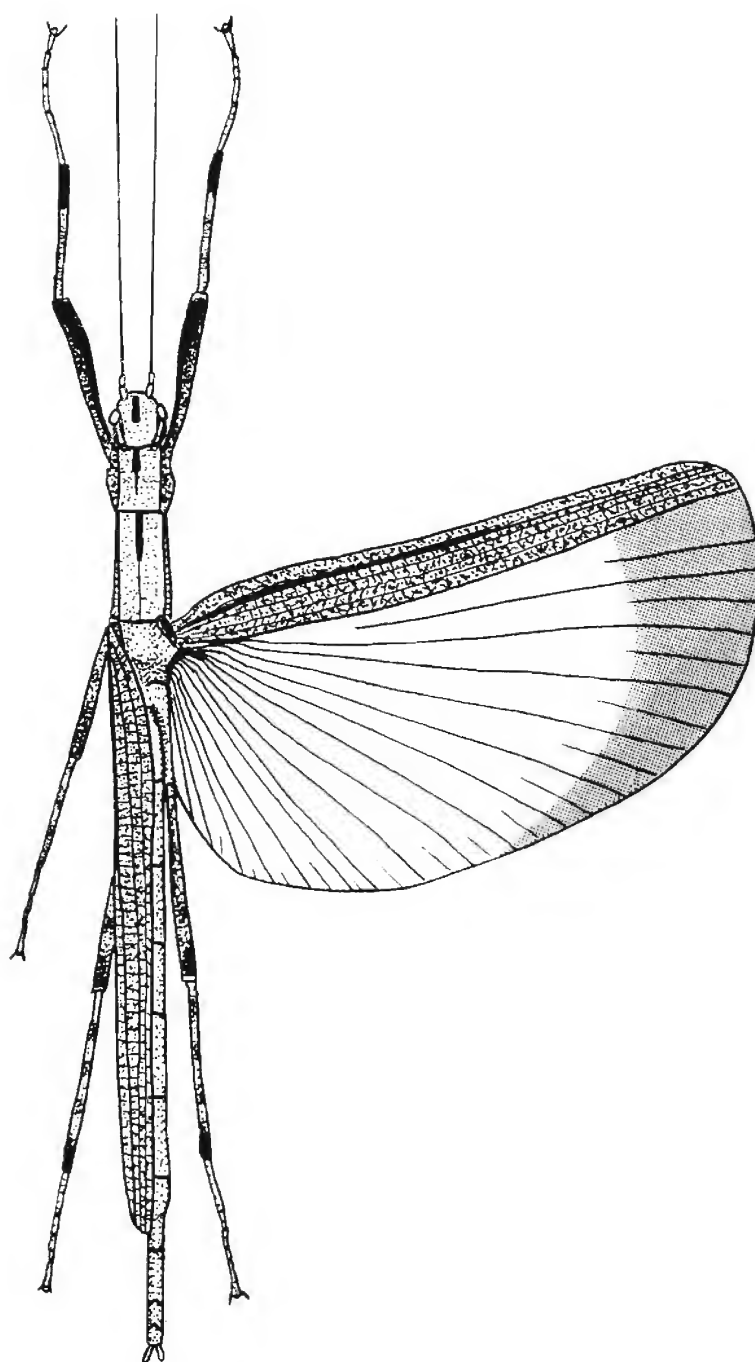


# PHASMID STUDIES.

**volume 5, numbers 1 & 2.**

June & December 1996.

Editor: P.E. Bragg.



Published by the Phasmid Study Group.

## Contents

PSG 103, <i>Sipyloidea</i> sp. from Thailand Robert Graham . . . . .	1
Further morphological variations in Bornean phasmids: <i>Carausius cristatus</i> Brunner, and <i>Lonchodes haematopus</i> Westwood Francis Seow-Choen . . . . .	7
A report on <i>Gratidia</i> sp. from Zaire (PSG 141), and a study of the hatching of the eggs Ingo Fritzsche . . . . .	13
A preliminary study of defence behaviour of <i>Sipyloidea sipylus</i> (Westwood) using amphibian predators Patrice Bouchard and Chia-Chi Hsiung . . . . .	18
Changes of taxonomy in giant stick-insects Paul D. Brock . . . . .	25
Redescriptions, synonyms, and distribution of two species of Lonchodinae from Borneo: <i>Lonchodes catori</i> Kirby and <i>Lonchodes hosei</i> (Kirby) P.E. Bragg . . . . .	32
Reviews and Abstracts Book Reviews . . . . . Phasmid Abstracts . . . . .	46 47
The influence of a cold period in the development of the embryo of <i>Clonopsis gallica</i> (Charpentier). W. Potvin . . . . .	55
A new culture of the subfamily Pachymorphinae from Thailand Mark Bushell . . . . .	59
Parthenogenesis explained Ewan More . . . . .	62
Reviews and Abstracts Meeting / Conference Reports . . . . . Book Review . . . . . Phasmid Abstracts . . . . .	70 70 71

## PSG 103, *Sipyloidea* sp. from Thailand.

Robert Graham, 6 Groesfford Fach, Llwyn Meredydd, Carmarthen, Dyfed, SA31 1EB, U.K.

Note on culture origin and identity by P.E. Bragg.

### Abstract

This paper describes the male and female adults of *Sipyloidea* sp. (PSG 103) and diagrams of each are present. It gives a general report of nymphs, defensive features and foodplants as well as a descriptive section on rearing techniques. An interesting difference in eggs is noted with the description of two variations both of which are figured. Three tables with comprehensive data of male and female lengths, instar lengths and nymphal growth are included.

### Key words

Phasmida, *Sipyloidea* sp., Thailand, Rearing, Foodplants, Eggs, Growth rate.

### Culture origin and Identification

This species was originally imported from Khao Yai National Park Thailand by Heinz van Herwaarden in August 1988 and was added to the PSG culture list as PSG 103 in Spring 1990. In his report on the species collected at the National Park, Heinz referred to this as "species eight" and illustrated the male, female and egg (Herwaarden, 1989: 17, figs 8a-8c). It does not seem to be a named species although the males are similar to a species described by Westwood from Singapore, and the females and eggs are similar to an apparently undescribed species from Mt Kinabalu in Sabah (the males of this latter species are quite different). The genus *Sipyloidea* Brunner, 1893, as treated by Redtenbacher (1908) is large in comparison to other phasmid genera and contains a rather diverse assortment of species, some of which appear to be misplaced. To further complicate matters, there are other genera which are, at least superficially, quite similar.

### Females (figure 1)

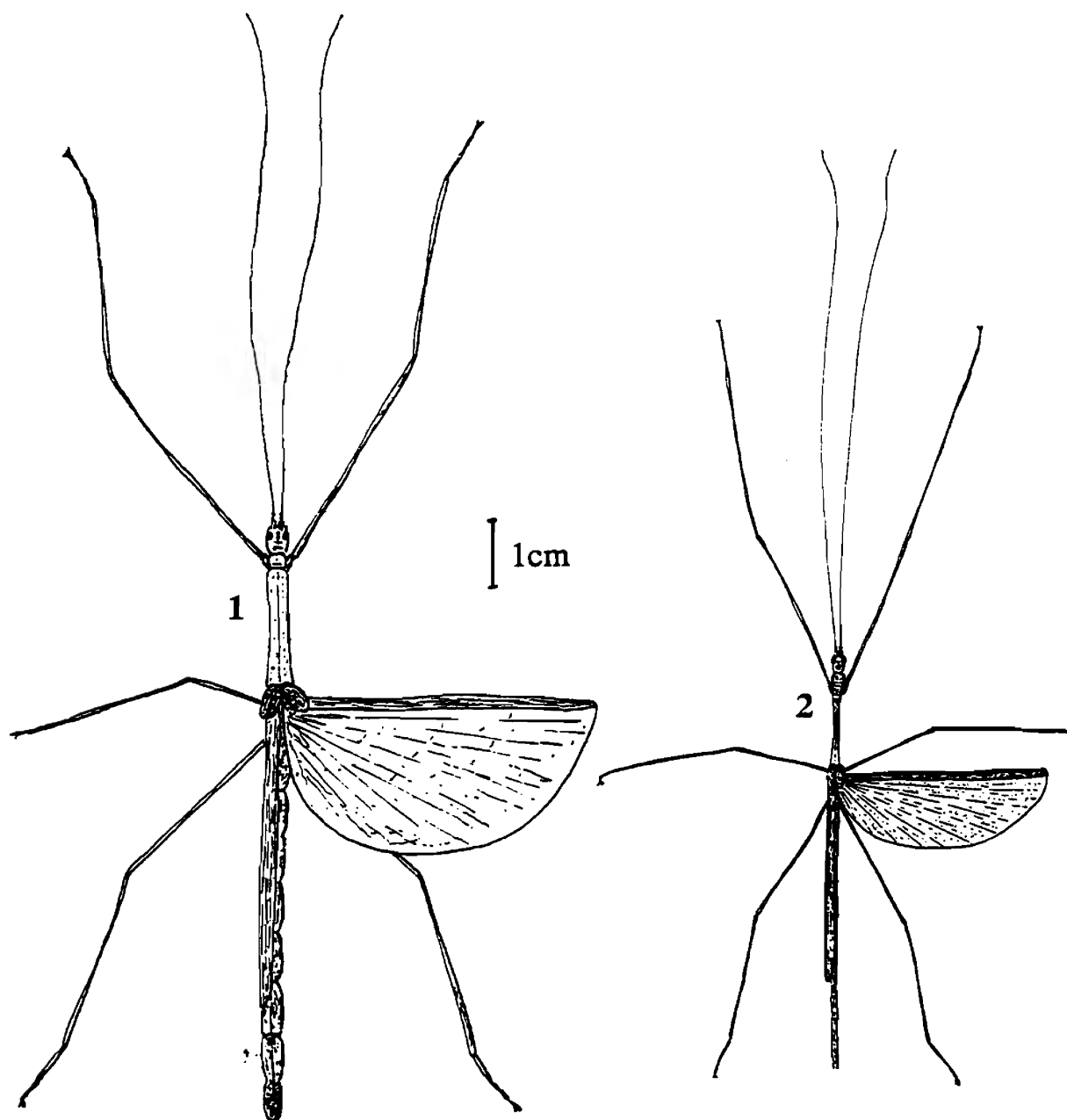
The females of this species are typical of the genus *Sipyloidea*. The females in captivity can have body lengths reaching 87mm, although other members have reported lengths up to 91-93mm. Table 1 presents a full set of measurements that have been recorded from a set specimen. The antennae are coloured a light straw-brown, with the first two segments being about twice the diameter of the rest. Typical body colouring is a medium brown to straw with darker patches on the head, pronotum and mesonotum giving a mottled appearance. The heads of my specimens had three narrow dark stripes running lengthways: two running from the pronotum to each eye, and one running in the middle of the fore head from the pronotum to the antennae. The latter stripe appears to continue the pronotum and mesonotum and stops at the elytra. There are no spines on the head or thorax but the texture of the mesonotum is slightly rough, similar to that of *Sipyloidea sipylus* (Westwood). The metanotum and abdomen are straw coloured, smooth in texture and have no pattern: there are no markings on the abdomen. The terminal segments are large, especially during egg production. The cerci are just visible, are small in size and flattened in shape.

The legs are all long and narrow. The fore and mid legs are a light straw-brown colour but are heavily mottled, giving the impression of being darker. In my experience the hind legs are of slightly deeper colour: a medium brown with quite dark markings.

There is a pair of well developed wings that span some 47mm. They are very pale brown and are devoid of the red veins that give the pink wing appearance of *Sipyloidea sipylus*. They are delicate and transparent.

### Males (figure 2)

Males of this species are extremely pretty and appear fragile compared to the much larger females. In captivity they can reach body lengths of 61mm and recordings of 69mm have



Figures 1 & 2. PSG 103 adults: 1, Female; 2, Male.

been reported. Table 1 gives full measurements of a set specimen. Antennae are the same length as the insect's body with the first two segments being a greater diameter than the others. The colour of the antennae is dark green to brown. Typical thorax and head colouring is dark green. The male has two stripes running along each side of the head, but appears to lack the stripe on the forehead which is quite pronounced on the female. However it is heavily mottled which gives a dark appearance.

The pronotum and mesonotum are smooth and devoid of any spines. There is a black and white stripe running in parallel on either side of the pronotum and mesonotum. These lines stop at the elytra. The mesonotum and abdomen are a slightly lighter colour than the head, being medium green. Beneath the wings the top side of the abdominal segments 1-5 are a medium brown colour. The abdomen has a shiny appearance and no mottled effect. The cerci project beyond the terminal segments of the abdomen and are pointed but flattened

in shape.

The fore and mid legs are the same colour as the head and slightly mottled. The hind legs are more brown in colour with the hind tarsi appearing medium brown. All legs are smooth, narrow and long in length relative to body size.

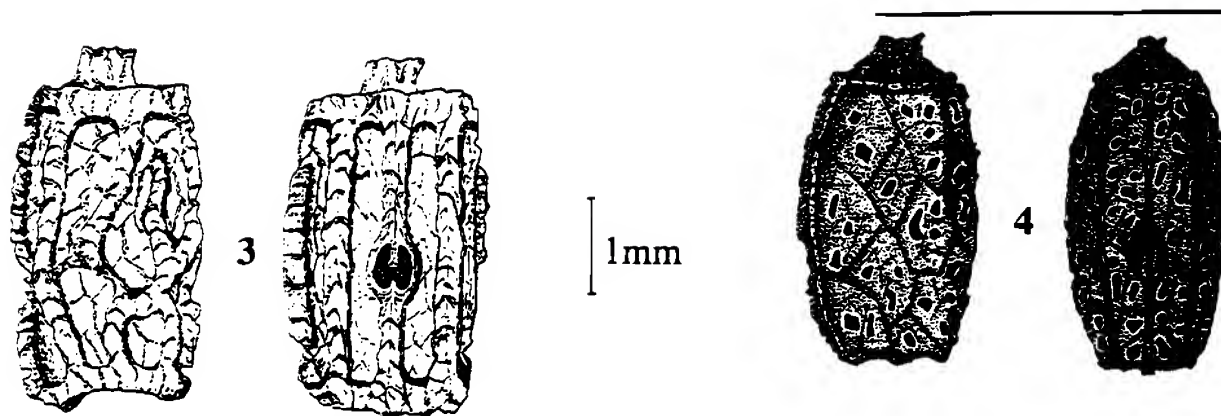
Adult sizes (mm)	Female	Male
Body length	87	61
Antennae	74	60
Head	4	2.6
Pronotum	3.5	3
Mesonotum	15	11
Metanotum	11	7
Abdomen	54	38
Fore femur	26	20
Fore tibia	24	19
Fore tarsus	11	7
Mid femur	15	13
Mid tibia	14	12
Mid tarsus	7	6
Hind femur	21	19
Hind tibia	20	18
Hind tarsus	10	8
Body width (metanotum)	4.2	2
Hind wing length	47	31
Fore wing length	6.5	3.5

**Table 1.** Measurement of adults.

Like the females they have a well developed pair of wings, they span 33mm. They are devoid of the brown coloration and are therefore almost colourless. The costal region of the hind wings are very brightly coloured with green and magenta-brown stripes. The wings appear very delicate.

#### **Eggs (figures 3 & 4)**

The eggs are rectangular to oval with the following dimensions: length 3.6mm, width 1.8mm and height 1.6mm. The colour is cream to medium brown. The operculum is of the same colour but the capitulum is often slightly darker. The micropylar plate is significantly darker than the rest of the egg, almost black in colour, and takes the form of a small oval, sometimes with indentations formed by the material of the capsule. The contents of the eggs are a greeny-cream colour.



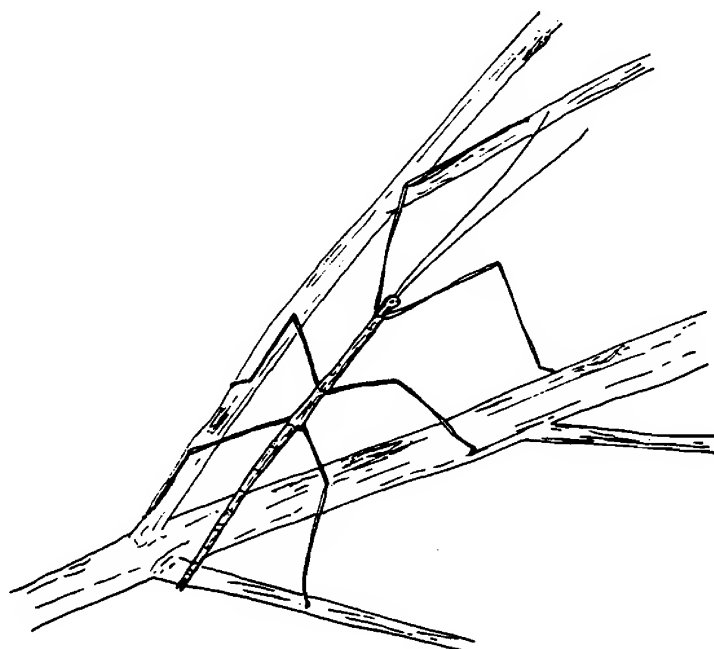
**Figures 3 & 4.** Lateral and dorsal views of eggs: 3, Original-type egg; 4, "B-type" egg.

The eggs described are of my first generation. I kept the eggs at room temperature in a plastic container. The humidity was about 60-70% and the eggs proved easy to keep. I had a 75% hatch rate. From these eggs I managed to rear three nymphs to adulthood - two females, one male. From the two females I received two different variations of eggs. One female laid eggs similar to those already described (see figure 3). The other female laid "B-type" eggs that were quite different (see figure 4). These eggs are slightly smaller with measurements of length 3.2mm, width 1.3mm and height 1.6mm. The eggs are much darker in colour, almost black. They have a smooth texture, devoid of the pits and projections of the original eggs. The operculum and capitulum are of similar shape but have a more shrivelled appearance. The micropylar plate is almost identical but less pronounced due to it being the same colour as its surroundings. The contents are similar being green in colour. Each female laid about 2.25 eggs per 24 hours and I incubated them in conditions similar to the first generation. With the original type eggs I had a hatch rate of 77% (n=82), and with the "B-type" eggs I had a hatch rate of 21% (n=104).

#### **Nymphs (figure 5)**

I have found that eggs can hatch at any hour but do so mainly at night between 2300 and 0600 hours. When newly hatched nymphs have a body length of 16mm. The body colour is a uniform bright green, darkening only slightly as the nymphs grow older. This is probably partly due to feeding and the darkening effect this has on the body. The mottling on the thorax of adults is apparent in the third to fourth instars.

Nymphs can be sexed in the third instar due to a difference in colour: males are more of a metallic blue-green whereas females remain bright green. A characteristic of this



**Figure 5.** PSG 103 nymph.

species is that the nymphs lie along the veins and midribs of the leaves, providing very good camouflage and making them very difficult to see. They often rest with their antennae at a 90° angle to their body.

There seem to be no apparent differences between the nymphs of the original type of egg and those established from the "B-type". I find this interesting as the eggs were so different. However there was a much higher rate of deformity and mortality among the nymphs hatching from "B-type" eggs giving me very few healthy nymphs.

Measurements (mm)	Instar No.											
	1st		2nd		3rd		4th		5th		6th	
	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂
Body length	16	16	24	24	32	32	42	40	54	51	69	-
Antennae	17	17	22	21	28	26	37	36	50	44	58	-
Fore leg	14	14	19	19	24	23	33	32	43	38	48	-
Mid leg	10	10	14	13	18	16	23	22	29	25	32	-
Hind leg	17	17	20	18	25	24	34	33	38	39	43	-
Body width (metanotum)	0.75	0.75	1	1	1.2	1	1.5	1.4	2	1.75	2.1	-

**Table 2.** Measurement of nymphs.

Table 2 shows the measurements of nymphs at each instar. These recordings were taken from one individual of each sex from the first generation reared. Checks were made with other insects from the culture to ensure the readings were accurate. Table 2 shows that both sexes grow at much the same rate and it is only the fact that males have one less instar than females that they are finally significantly smaller in size. The length of the instars of each sex is shown in Table 3. This data was taken from the same two individuals and shows that on average the male had longer instars than the female.

Instar No.	Duration (days)	
	Female	Male
Eggs	59	59
1	27	30
2	24	31
3	25	23
4	23	32
5	35	31
6 (♀) / adult (♂)	34	88
Adult	93	-

**Table 3.** Length of instars.



## Defence

Defence mechanisms of this species are mainly passive: lying along the veins and midribs of leaves. When disturbed, many forms of active or secondary defence occur. Both nymphs and adults attempt to escape by falling or walking away. I have experienced female adults hurling themselves to the floor of the cage. This may be similar to the "push-back fright response" as described by Bradburne (1993). Although females have well developed wings, Bradburne explains that if the insect has less than 30cm to drop, it declines to use its wings. However both adult sexes are active fliers and this is probably their main form of defence.

Males in particular are very capable fliers and "they easily manage to dodge around obstacles" (Bradburne, 1993). I can only believe that this is a great asset in the wild when they have to defend themselves against predators.

## Foodplants

This species readily accepts hawthorn (*Crataegus* sp.), bramble (*Rubus* sp.), rose (*Rosa* sp.), eucalyptus (*Eucalyptus* sp.), raspberry (*Rubus idaeus*), lime (*Tilia* sp.). The female adult especially gorges itself on bramble flower petals. It could be that it is attracted to coloured or scented plants. Flower eating has also been recorded in *Sipyloidea sipylus* by Adams (1990). It may therefore be that this feature occurs across the whole genus.

The above list are the only plants tried apart from ivy (*Hedera* sp.) and apple (*Malus* sp.) both of which were rejected.

## Rearing

Apart from the difficulties incurred during the hatching of the "B-type" eggs I found this to be one of the easier species to rear and have successfully reared two generations. I have heard of no reports of difficulty in rearing this species.

From initially receiving a total of eight eggs to start my culture, I kept them in conditions as previously described. They commenced hatching on 30-11-94 with a 75% success rate achieved. From these 6 nymphs three adults were raised, one male and two females. They reached their adult stage on 29-4-95, 17-5-95 and 18-5-95 respectively. I first noticed copulation occurring on 20-5-95 and the first eggs were laid on 5-6-95; these were of the "B-type".

Approximately 150 eggs were laid by each female at an average rate of 2.25 eggs per 24 hours. Laying occurred until death. No apparent change in egg size occurred as death of the female approached, a contrast to species such as *Extatosoma tiaratum* (Macleay) where shrinkage occurs. The male died on 26-7-95 and the females died on 8-8-95 and 18-8-95. Having only so far reared one generation to the adult stage I cannot be sure they lived a full lifespan although I am unaware of any reason for them to have died prematurely.

I kept this species in wood and gauze, or plastic cages, and spray them with water four times a week. I have found that spraying was not critical and that they can survive in a fairly dry atmosphere at normal room temperature.

## References

- Adams, M. (1990) Flower eating and defence in *Sipyloidea sipylus*. *PSG Newsletter*, 43: 13.  
Bradburne, R.P. (1993) Defensive and flying behaviour in *Sipyloidea* sp. (PSG 103). *Phasmid Studies*, 2(2): 56-58.  
Herwaarden, H. van (1989) Phasmidae from Thailand, Part 2: Species found in Khao Yai National Park. *PSG Newsletter*, 41: 15-19.  
Redtenbacher, J. (1908) *Die Insektenfamilie der Phasmiden*, Volume 2. Leipzig.



# Further morphological variations in Bornean phasmids: *Carausius cristatus* Brunner, and *Lonchodes haematomus* Westwood.

Francis Seow-Choen, 54 Mimosa Walk, Singapore 2880.

e-mail: gcscsf@sgh.gov.sg.

## Abstract

Some morphological variations in *Carausius cristatus* Brunner, and in *Lonchodes haematomus* Westwood are illustrated and discussed.

## Key words

Phasmida, variations, Borneo, *Carausius cristatus*, *Lonchodes haematomus*.

## *Carausius cristatus* Brunner

Following the excellent article by Bragg (1995) I decided to check my specimens of *Carausius cristatus* Brunner as well as make some notes of variations in my series of *Lonchodes haematomus* Westwood. Bragg's original collection, of 4 female specimens in 1990, obviously bred true to their maternal phenotype. His second collection of two females resulted in some offspring having the head, mesonotum and fifth abdominal crests as figured by him.

I collected four mating pairs of *C. cristatus* on the Silau Silau trail near Mount Kinabalu National Park Head Quarters in Sabah whilst on a collecting trip with C.L. Chan in 1993. Three of my four wild caught females showed different variations from those illustrated by Bragg whilst only one was similar to the female of Bragg's 1990 collection. All the males were exactly alike and appeared to be no different from those illustrated by Bragg.

## Females (Figures 1A-1C)

I will not attempt to repeat the very good description of *C. cristatus* laid out by Bragg, except to point out the further variations in my wild caught females.

Specimen A (fig. 1A) was most like Bragg's original specimens. Coarse granulations were however prominent over the mesonotum, metanotum, mesosternum and metasternum, as well as the 3rd, 5th and the 6th abdominal segments. The end of the 7th, 8th and 9th abdominal segments were prominently raised, albeit only slightly above the contour of the top of the following abdominal segments as illustrated.

Specimen B (fig. 1B) had coarser granulations over the mesonotum and the metanotum; almost blunt rose-thorn like in shape. Coarse granulations were again present over the mesosternum and the metasternum and over the 2nd, 3rd, 4th and 5th abdominal segments. A prominent tubercle was present on the lateral sides of the 5th and 6th abdominal segments. There was a raised ridge-like elevation over the caudal end of the 7th abdominal segment. The caudal end of the 8th and the 9th abdominal segments were also very markedly raised as over-hanging protuberances.

Specimen C (fig. 1C) displayed the most prominent tubercles of the three specimens. There were numerous rose-thorn like tubercles over the mesonotum and several over the metanotum. Coarse granulations were present as usual over the mesosternum and metasternum. Prominent tubercles were found over the 2nd, 5th and 6th abdominal segments. The two lateral tubercles over the 5th and 6th abdominal segments in this specimen being large and like the tail-wings of an aeroplane.

## *Lonchodes haematomus* Westwood

*Lonchodes haematomus* is a species which is very common in parts of Borneo. This species has been found in Sarawak, Brunei and Sabah. I have collected this species from Sabah and

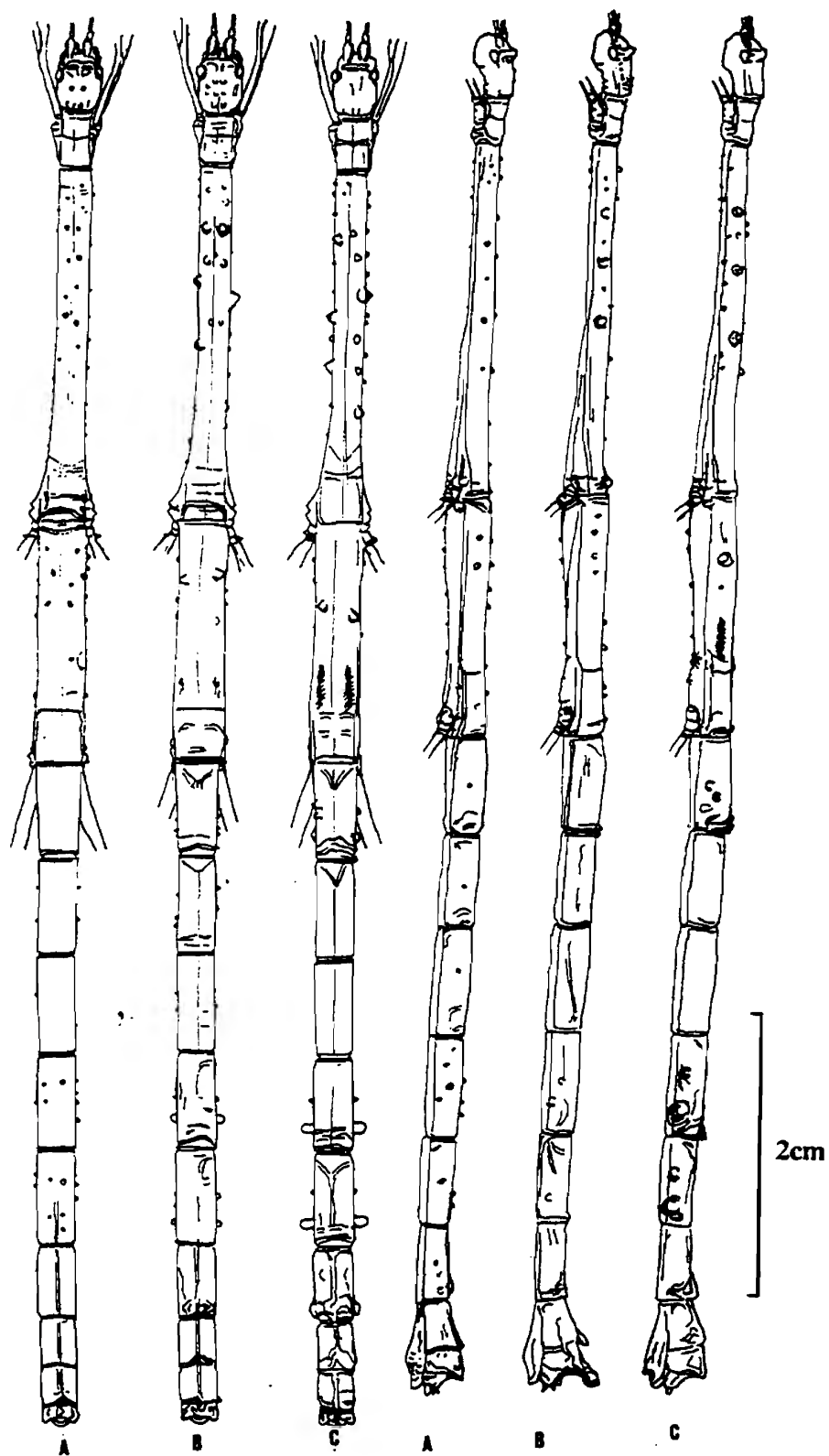


Figure 1. Females of *Carausius cristatus*.

Brunei as well as raised specimens from eggs collected from Sarawakian specimens. This species is extremely easy to breed in captivity and readily takes *Rubus fruticosus* as well as *Rubus moluccanus*. Although I have reared specimens of this species in a large mixed cage in the garden, offspring of mixed ancestry were not studied and the phasmids illustrated represent only those phasmids that were wild caught or hatched from eggs of females that were mated in the wild.

This is a species which, in common with many other *Lonchodes* species, shows great variation in external morphology in the female whilst males of the species do not show any variability in external form. The adult male is illustrated in figure 2. Variations in the adult female are shown in figure 3. Females from Brunei tend to have less humps and swellings on the abdomen and thorax, whereas females from Sabah are the opposite and are often well endowed with prominent protuberances.

<i>L. haematomus</i>			♂		♀	
			Fore femora	17-23	17-22	
			Fore tibiae	17-28	16-21	
			Fore tarsi	5-6	6	
			Mid femora	14-18	15-18	
			Mid tibiae	10-13	12-14	
			Mid tarsi	5.0-5.5	5.0-5.5	
			Hind femora	16-22	17-20	
			Hind tibiae	16-22	15-20	
			Hind tarsi	5-6	6	
			♂	♀		
Total length	112-150	144-174				
Antennae	36-57	34-38				
Head	3-4	5-6				
Pronotum	3.0-3.5	5.0-5.5				
Mesonotum	21-28	26-32				
Metanotum	12-17	14.0-17.5				
Abdomen *	39-51	62-73				

**Table 1.** Measurements of the longest and shortest specimens of *Lonchodes haematomus* in the author's collection. \* The length of the abdomen includes the median segment.

### Illustrations of variation in *Lonchodes haematomus* females (figure 3)

Specimen A (figs. 2A & 3A) was wild caught at Sepilok, Sabah. It lacked the prominent mesonotal swelling, there is also a noticeable black dot on the median segment as well as on the fifth abdominal segment.

Specimen B was also found at Sepilok. This specimen has the mesonotal swelling (but the apex of the abdomen is very similar to specimen A) and it also shows the black dot on the median segment and the fifth abdominal segment.

Specimen C is also from Sepilok. The mesonotal swelling is present but there are also smaller swellings on the second, fifth, sixth and seventh abdominal segments. The last abdominal segment also shows a longer extension than in the specimens illustrated so far in this paper.

Specimen D was raised from eggs laid by an insect caught in Sabah. It was like specimen C in general form although the abdominal apex was similar to A.

Specimen E was caught at Rampayoh Waterfalls in Brunei. This phasmid was similar to specimen A but for the length of the extension of the last abdominal segment.

Specimen F was found at Sepilok. The operculum is keeled and protrudes beyond the end of the last abdominal segment.

Specimen G is from Sepilok. It has raised prominences at the end of the mesonotum, and ends of the eighth and ninth abdominal segments.

Specimen H is descended from Brunean stock and shows the extension of the last abdominal segment.

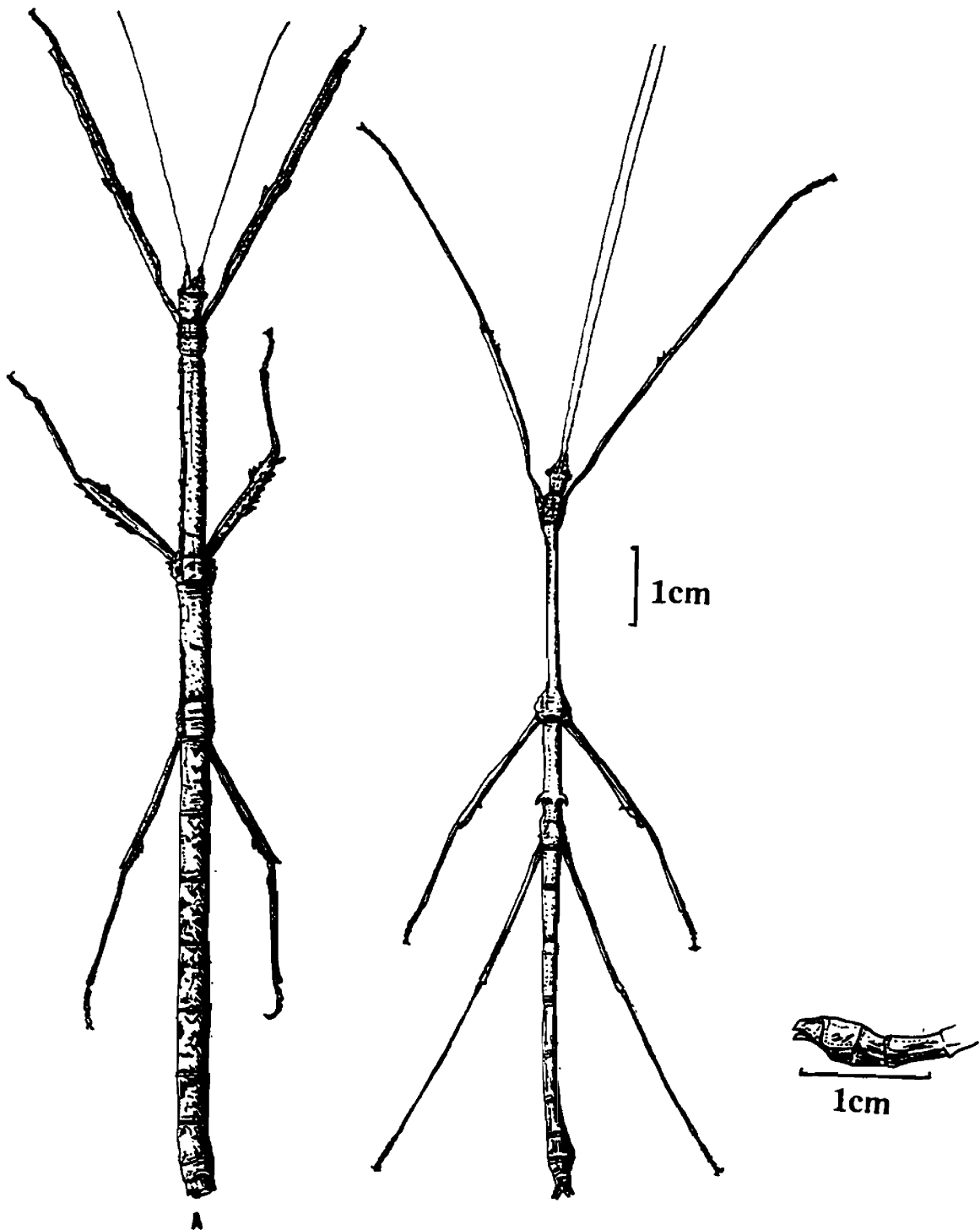


Figure 2. *Lonchodes haematopus*, female, male and apex of male's abdomen.

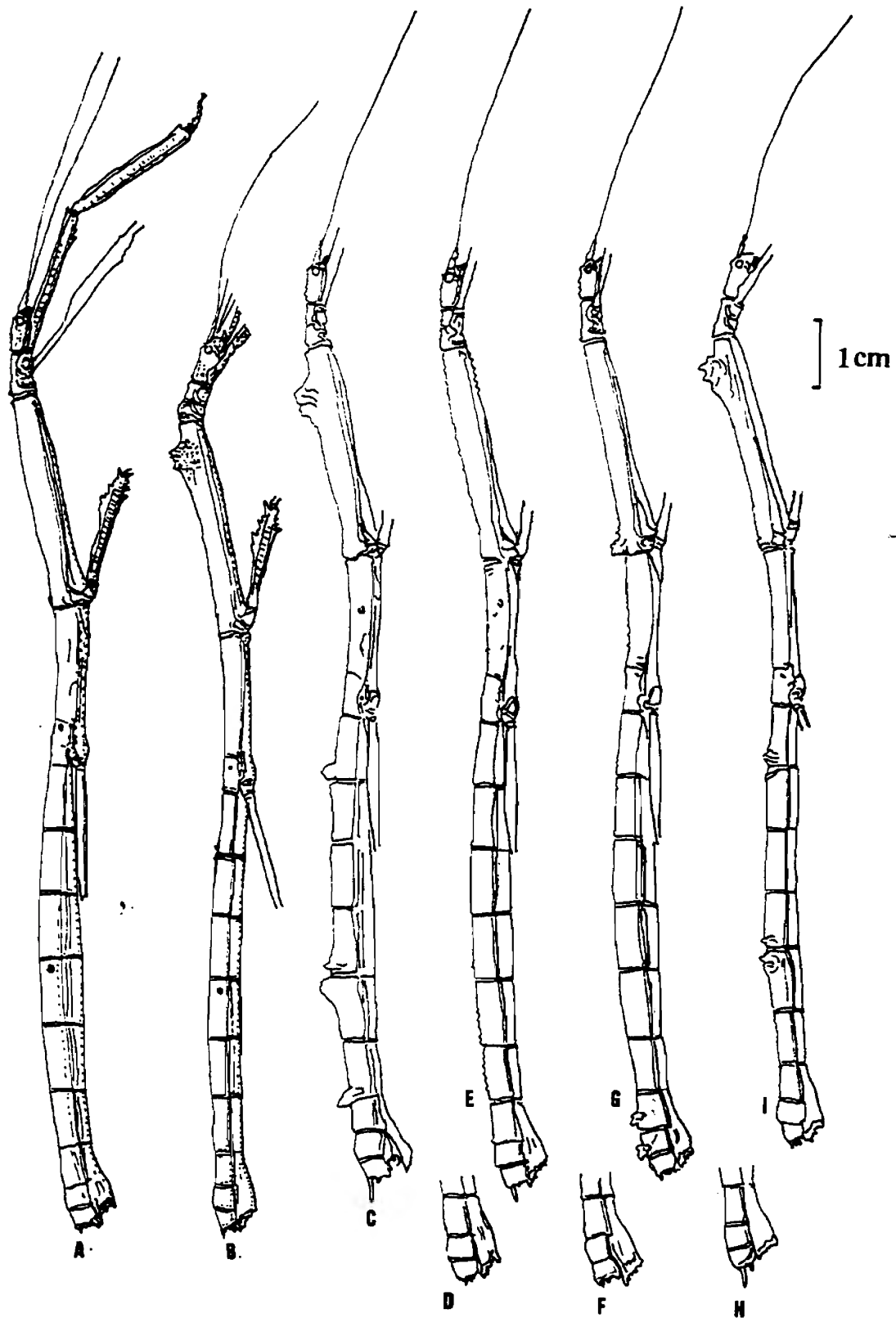


Figure 3. *Lonchodes haematopus*, lateral views of females. For details see text.

Specimen I is similar to specimen C, but with the swellings less fully developed.

It can be seen from the illustrations that *Lonchodes haematopus* is indeed a very variable insect. Numerous collecting trips in the region have led me to be wary of labelling any collected insect as new until a long series of both wild caught and captive bred specimens have been reviewed, otherwise the taxonomy of the phasmids will not ever be cleared of synonyms and confusion.

### References

**Bragg, P.E.** (1995) Variation in three Bornean species of Lonchodinae: *Carausius cristatus* Brunner, *Lonchodes modestus* (Brunner) and *Lonchodes strumosus* (Brunner). *Phasmid Studies*, 4(2): 70-86.

Units E & F  
Mark Grove House  
Allen Road  
Rushden  
Northants  
NN10 0DU  
  
01933 56894

**CUSTOM  
AQUARIA**

DESIGN AND MANUFACTURE  
OF SPECIALIST ALL GLASS  
VIVARIA  
AQUARIA  
SMALL ANIMAL CAGES

SUITABLE FOR  
REPTILES  
AMPHIBIANS  
INVERTEBRATES  
FISH  
SMALL MAMMALS

STOCKISTS OF FOOD, SUBSTRATES, HEATING, LIGHTING, BOOKS, &  
OTHER ACCESSORIES

USE YOUR IMAGINATION !

SEND US YOUR OWN DESIGN  
CATERING FOR YOUR PARTICULAR NEEDS.....  
HOWEVER WITH A STANDARD RANGE  
OF OVER 250 STYLES AND SIZES  
WE PROBABLY ALREADY PRODUCE IT!

CUSTOM ONE-OFFS WELCOMED  
TRADE AND RETAIL SUPPLIED

SEE US AT ALL THE MAJOR EXOTIC ANIMAL SHOWS

# A report on *Gratidia* sp. from Zaire (PSG 141), and a study of the hatching of the eggs.

Ingo Fritzsche, Huberstrasse 1, D-38855 Wernigerode, Germany.

Drawing of egg by Oliver Zompro.

## Abstract

The adults of an unidentified species of *Gratidia* from Zaire (PSG 41), are briefly described. The egg is illustrated and data on egg laying rates, incubation time and hatch rates are presented.

## Key words

Phasmida, *Gratidia* sp., rearing, eggs, laying, incubation, hatch rate.

## Introduction

This species belongs to the family Heteronemiidae, sub-family Pachymorphinae, tribe Gratidiini, and genus *Gratidia* Stål; the species is unidentified. This species was previously referred to *Ramulus* Saussure (see Bragg, 1995). A lot of species belongs to this genus and the determination is very difficult, because the differences between the species are very slight. The culture originated in Zaire.

## Male

The male is about 50-58mm in length and has a colour varying from green to brown, with a reddish mesothorax and metathorax. There is a green stripe on the mesothorax and metathorax on both sides of the thorax. The legs are very long. The femora of the middle and hind legs are greenish. The tibiae and tarsi are brownish. The coxa are greyish. There are no spines on legs or body. The antennae are 13-14mm long with 17 segments and are a beige colour. A lot of fine hairs are on the antennae. The head is beige and has a brown stripe on each side. The abdominal apex is yellowish and as broad as the body. Two cerci situated on the abdominal apex look like a hoop.

## Female

It has a greenish or brown colour of the body, with a length of about 75-80mm. The width of the 3rd and 4th abdominal segments is about 2.5-3.0mm. The inter-segmental skin is white. The colour is very variable depending on the humidity in the cultures. The antennae are shorter than the male's antennae; they have 18 segments but are only 5-6mm long. The sub-genital plate is very long, it reaches to the end of the abdomen. The cerci are much longer than the end of the abdomen.

## Nymphs

When the nymphs hatch they have a length of 11-13mm. The colour is yellowish or pale yellow-white. The body is like a thread. The nymphs change their skin 6 or 7 times. After 4 months they are adults.

## Eggs

The eggs have a lengths of 4.6mm and a width of 1.0mm and a height of 1.2mm. An egg in profile lets us see that the operculum is tilted towards the micropylar plate (fig. 1). The colour is beige. The operculum is flat with irregular marks. On the sides of the operculum we can find a crown of spines. The micropylar plate is a very small ellipse, which is enclosed by a strip running from the operculum edge to the polar end. The eggs are glued to the side of the cage or to the foodplant.



Figure 1.  
Egg of PSG 141.



The laying and hatching dates for one female.

February laid hatched in April in April in April	1	2	3	4	5	6	7	8	9	10	11	12	13	14 adu	15	16	17	18	19	20 cop	21	22	23	24 cop	25 2	26 3 3	27 2 2	28 2 1					
																										23 23	24 26						
March laid hatched in May	1 4	2 2	3 4 1 1	4 2 2 4 7	5 3 1 2 7	6 3 3 2 4 7	7 0 0	8 2	9 2 1 6	10 3 1 6	11 3	12 2	13 2 1 12	14 3 3 8 10 10	15 3 1 18	16 4	17 4	18 4 4 11 12 12 20	19 4 2 13 13	20 5	21 3 1	22 0 0	23 2 1 20	24 4 2 18 20	25 3	26 5 5 20 21 22 22 27	27 5	28 0	29 6 2 18	30 1	31 3		
in June																					1								1				
April laid hatched in May in June	1 2	2 4	3 2 1 28	4 2 1 28	5 4 2 30	6 2 2 1 6 6	7 2	8 0	9 3 2 6 9	10 2 1 4 3	11 3 1 7	12 4	13 3 2 7 9	14 2 2 7 11	15 2 2 9 11	16 3 3 10 11	17 4 1	18 2 1	19 4	20 3 2 13 13	21 3 2 14 17	22 3 1 17	23 3	24 2 1 17	25 0	26 3 3 22 25 25	27 2 1 17	28 2 2 22	29 2 1 23	30 4 4 23 23 29 2			
in July																																	
May laid hatched in June in July	1 2 1	2 2 1	3 4	4 1	5 3	6 1 1 30	7 2	8 1	9 4 2 30 3	10 4 1 3	11 4	12 5 1 4	13 2 1	14 0 0	15 4 1	16 1	17 3	18 0 0	19 2	20 2 1 8	21 5 3 8 12 12	22 3	23 4	24 3	25 2	26 0 0	27 2 2	28 3	29 3 1	30 4 1	31 1 1		
June laid hatched	1 2	2	3	4	5 dead	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30			

### Egg laying behaviour

The female searches with her front legs and the antennae for a good place for the egg. If she has found one, she bends her abdomen end between the antennae, over her thorax. The antennae place the eggs in the right position; the legs help them, but the most work is done by the antennae. Usually *Gratidia* lays her eggs in the same place, so we can find in a cage a lot of eggs in the same place.

### Defence reaction

When concerned the phasmids form a ball for the first defence reaction. All legs, the abdomen and the thorax form a ball. The legs get lifted under the thorax, and the abdomen goes over the thorax to the head. In this situation she jumps at short intervals, similar to a tree in a strong wind. The second reaction is the autotomy of the legs, she loses her legs. Avoid all physical contact with the legs, if you want phasmids with all their legs.

### Breeding conditions

The insects need good climatic conditions, with a good ventilation and low humidity (40-60 % RH). I keep them in 22-25°C. From time to time I sprayed in the cage a little bit of water. If there is a high humidity (60-90% RH), you will lose the most of your insects due to diarrhoea and losing the legs.

### Foodplants

Bramble is the favourite, raspberry, and strawberry are also eaten. Oak and ivy are also possible but are not so good for successful breeding.

### The study of egg hatching

Lelong (1995) wrote that the hatching date of the nymphs is one month after the laying date. I can not agree with this, because my results about the hatching dates these eggs showed something different. I kept 5 females and all were in separate cages. I collected all laid eggs

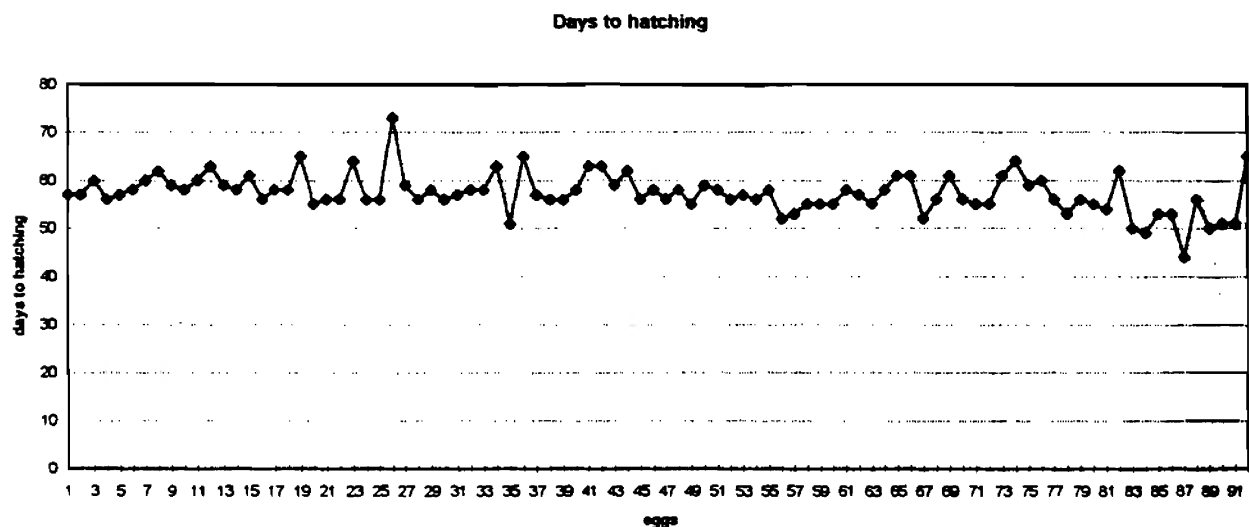
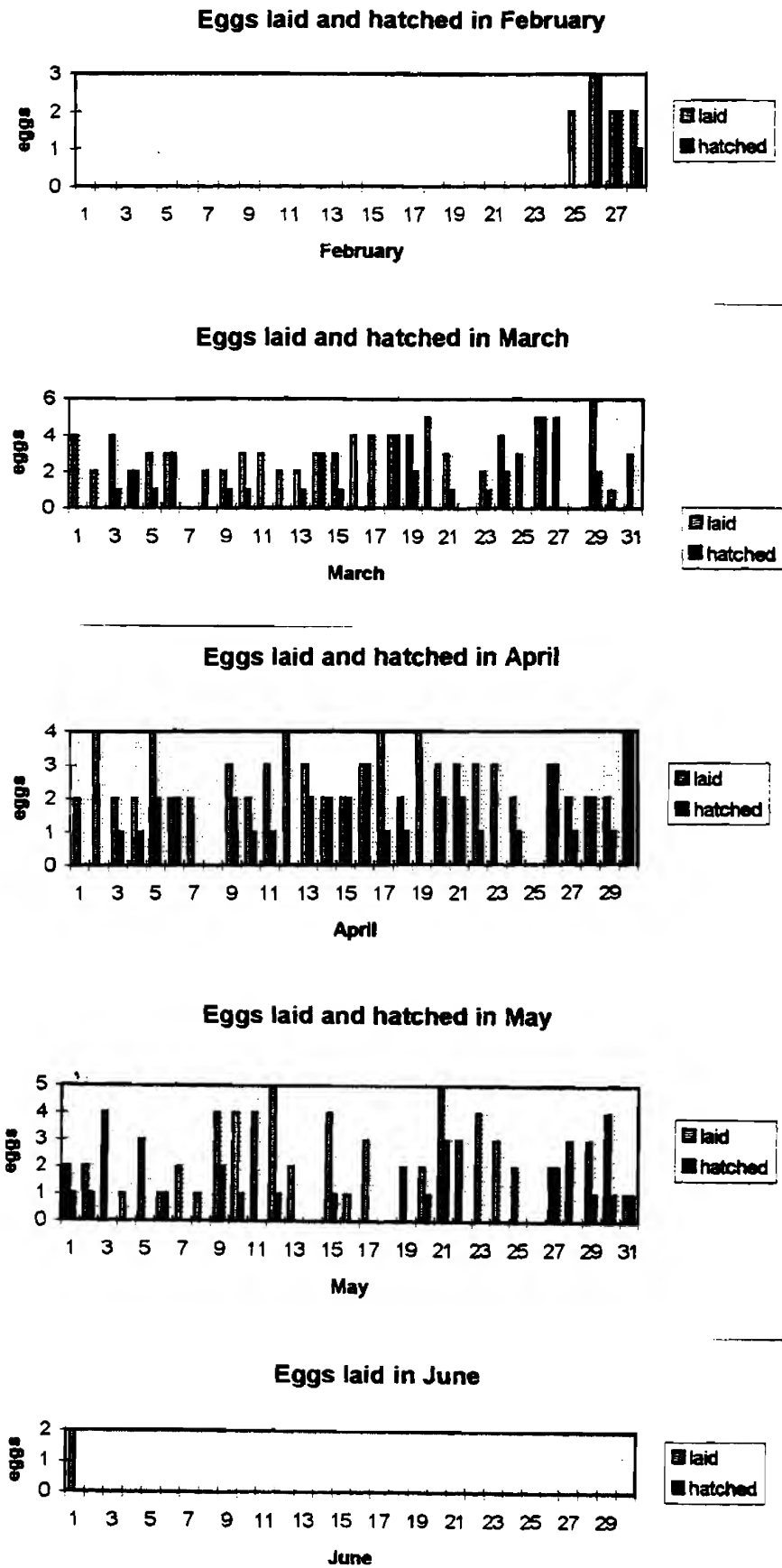


Figure 2. Incubation time for eggs of PSG 141.



**Figure 3.** Number of eggs laid on each day, and number of those which hatched.

and separated them into small jars for each day. The eggs were kept in separate jars with the date of laying and the number of the laid eggs on this day. There were the same conditions in each jar; the conditions were about 50-60% RH and 22-25°C. The eggs hatched out two months after laying. Most eggs hatched in the morning, between 0600 and 0800.

Table 1 gives the laying and hatching dates for all the eggs from one female. For each day of the insect's adult life the table gives the number of eggs laid, the number of those eggs which hatched, and the dates on which they hatched. The row for the number of eggs laid is also used to indicate the dates on which the insect became adult ("adu"), dates when copulation was observed ("cop"), and the date on which it died ("dead"). The data for this female is similar to the average. From 255 eggs, 92 hatched out, a hatching rate of 36%. The mean incubation period was 57.4 days, with a range of 44-73 days. These rates varied very little between the five females. Figure 2 illustrates the variation in incubation time. Figure 3 shows the number of eggs laid each day, and how many of these hatched.

I can not believe that hatching rates of 80-90% recorded for most species is normal. If you start culturing a species with 30 or 40 eggs such hatching rates are probably possible, but mostly you will not get this result with all the eggs laid. In most articles we can find a high hatching rate stated, but the culture was started by 30 or 40 eggs.

### References

- Bragg, P.E.** (1995) Type species of phasmid genera with particular reference to the status of *Baculum* Saussure, 1861, *Ramulus* Saussure, 1862, and *Gratidia* Stål, 1875. *Phasmid Studies*, 4(2): 11-14.  
**Lelong, P.** (1995) *Ramulus* sp. PSG n° 141. *Le Monde des Phasmes*, 30: 26-28.

## Advertising in Phasmid Studies

*Phasmid Studies* has a worldwide circulation of about 500 copies. Full-page, half-page or quarter-page adverts can be accepted. For details of the costs and restrictions contact: P.E. Bragg, 51 Longfield Lane, Ilkeston, Derbyshire, DE7 4DX, U.K.

# A preliminary study of defence behaviour of *Sipyloidea sipylus* (Westwood) using amphibian predators.

Patrice Bouchard and Chia-Chi Hsiung, Lyman Entomological Museum and Research Laboratory, Macdonald Campus of McGill University, 21 111, Lakeshore, Ste-Anne-de-Bellevue, Québec, Canada, H9X 3V9.

## Abstract

In a small number of trials, large nymphs of *Sipyloidea sipylus* (Westwood) were offered to three species of amphibians. Non-moving prey were ignored by all the predators. Phasmids which moved were eaten by only one species of amphibian. Results suggest that the chemical defences of *S. sipylus* offer little protection against amphibian predators but remaining immobile is an effective defence.

## Key words

Phasmida, *Sipyloidea sipylus*, Nymphs, Behaviour, Defence, Amphibian.

## Introduction

The stick insect *Sipyloidea sipylus* (Westwood, 1859) was originally described in the genus *Necroscia*. It is distributed in South East Asia (Westwood, 1859: 139; Redtenbacher, 1908: 544), including Taiwan (Shiraki 1935: 80), where it is bisexual. More recently, a parthenogenetic stock has been introduced and established in Madagascar (Chopard, 1954). The culture stock derived from Madagascar consists of parthenogenetic females with males occurring rarely (Urvoy, 1969). *S. sipylus* is a slender stick insect. The body colour of the adult is light brown with well developed pink wings and the body of the nymphs is green. In the immature stage, six well distinguished nymphal instars occur (Carlberg, 1981a & 1987), unlike the results observed by Browaeys-Poly (1973) in which seven nymphal instars were documented.

According to Robinson (1969), the anti-predator adaptations of insects could be classified into primary and secondary defence systems. In the case of *S. sipylus* the two main types of defence mechanisms for protection can be identified as follows: the primary defence system consists of grass mimicry (camouflage) and it also uses a chemical secretion as a secondary defence system (Carlberg, 1981b). The chemical secretion is produced by a pair of metathoracic glands which have been described by Rabozzi and Dazzini (1972). Other types of defence strategies have been observed in this insect such as thanatosis, running and the display of the pink wings by the adults (Carlberg, 1981b & 1981c).

In recent years, the defensive behaviour of some stick insects has been investigated using live predators as opposed to using forceps or a finger as stimuli which was the case in the studies mentioned above. Carlberg (1985a) studied the defence system of *Anisomorpha buprestoides* (Stoll) using a small rodent, *Rattus norvegicus* (Berkenhout) as a predator. The results obtained showed that the defensive secretion of *A. buprestoides* acts as a repellent against the rodents and therefore enables the stick insects to escape predation in most cases. In the same line of investigation, other stick insects such as *Extatosoma tiaratum* (MacLeay), *Carausius morosus* (de Sinéty), *S. sipylus* and *Eurycantha calcarata* Lucas were exposed to rodent predators to study their different defence behaviour (Carlberg, 1985b, 1985c, 1986, & 1989 respectively). In the study of the defence behaviour of fifth instar female nymphs of the stick insect *S. sipylus* using the rat *Rattus norvegicus* (Carlberg, 1986), four series of tests were performed with each rat. The results showed that only 20% of the insects were eaten when put in presence of a rat proving that the chemical defence of *S. sipylus* is more powerful than those of *E. tiaratum* and *A. buprestoides*. In the few instances where the nymphs of *S. sipylus* were killed, the rats had to make a large number of attacks before they were able to kill the stick insects. *S. sipylus* is thought to be a more or less ground living stick insect (Carlberg, 1981b & 1986) (although evidence of a more arboreal preference can be observed in culture stocks) implying that it would be exposed to many types of predators



(other insects, small mammals, lizards, frogs and birds) in its natural habitat.

Since the defence behaviour of *S. sipylus* seems to be very effective against rodent predators, as shown by Carlberg (1986), it would be interesting to test the effectiveness of the chemical secretions and other defence systems used by this insect when confronted with amphibian predators.

## Material and methods

### Animals

Female nymphs of *S. sipylus* were supplied by the Insectarium of Montreal, and kept in mesh cages at room temperature (about 20°C). All of the insects were fed with Red oak (*Quercus rubra* Linnaeus) and guava (*Psidium guajava* Linnaeus) leaves. Only the nymphs of the last (6th) instar were used in this experiment (body length:  $78 \pm 4$  mm).

Two males (initial mass of body:  $139.9$  &  $163.2 \pm 0.05$  grams) and one female (initial mass of body:  $193.4 \pm 0.05$  grams) adult Bullfrogs (*Rana catesbeiana* Shaw) were kept at the Ecomuseum, in an indoor reproduction of their natural North American habitat. The Bullfrogs were fed with domestic crickets *Acheta domesticus* (Linnaeus) (25 each every eight days) and also baby mice (4-5 grams each, given once every five days).

One male (initial mass of body:  $38.0 \pm 0.05$  grams) American Toad (*Bufo americanus* Halbrook) and one male (initial mass of body:  $45.0 \pm 0.05$  grams) Green Frog (*Rana clamitans* Latreille) were kept in separate 5 US Gallon glass tanks ( $40.5 \times 25.4 \times 20.3$  cm) at the Ecomuseum. Both were fed with domestic crickets (10 every eight days).

### Experiments

All of the predators were fed a feeding cycle which was used previously by Carlberg (1985 b, c, 1986, 1989). The predators received food for eight days (prefeeding), then they were given no extra food on the ninth and tenth days (starvation). All of the tests were made during the eleventh day of the cycle. Three series of tests were performed with each of the predators in 5 US Gallon glass tanks. The insects used were used only once. The duration of the tests was 15 minutes.

The first predator-prey behavioural response (FPPBR) was recorded and this is defined as the first behaviour of the insect when introduced inside the glass tank containing the potential predator. The sum of all of the predator-prey behavioural responses during the 15 minutes of each test is defined as the total predator-prey behavioural response (TPPBR). The results are presented for each species. For each test, one nymph was introduced by hand into the cage where only one predator had been placed.

To clarify the data obtained in the three tests with *S. sipylus*, the same predators were used in four other tests as follows: 1 - with three live domestic crickets; 2 - with three freshly killed domestic crickets (killed by putting them in a freezer for ten minutes); 3 - with three treated crickets (done by shaking vigorously the live crickets and specimens of *S. sipylus* in a plastic bag for about 15 seconds); 4 - with one specimen of an unidentified stick insect of the genus *Bacteria* (PSG culture 152, from Venezuela), with average lengths of 85.2 mm. The last four tests were done using exactly the same procedure as for the first three tests.

### Results

The first reaction of the insects (FPPBR) when introduced inside of the cage with the predators is shown in Table 1. The nymphs walked forward in most of the cases (87%,  $N_{\text{total}} = 15$ ) independently of the size or the species of the predator. Out of the total number of nymphs that moved in the FPPBR, three of them stimulated the predator by their movement

and as a result they were attacked and later eaten. The three times that the insects were ingested, they were attacked by the same predator in the three different tests, the Green frog. The manipulation of the nymphs triggered them to use their chemical defence in some, perhaps every, instance as a strong smell could be detected on the hands of the manipulator.

Bullfrogs	American toad	Green frog
89% ME*	66% ME*	100% ME
11% M*E*	33% M*E*	

**Table 1.** FPPBR for all the tests combined and for each of the species.

Note: M= moving prey; M\*= non-moving prey; E= eaten by predator; E\*= rejected by predator.

Bullfrogs	American Toad	Green Frog
100% M*E*	100% M*E*	100% ME

**Table 2.** TPPBR for all tests combined for each of the species.

Note: M= moving prey; M\*= non-moving prey; E= eaten by predator; E\*= rejected by predator.

Data was also recorded concerning the total predator-prey behavioural response (TPPBR). The results show that most of the insects (80%,  $N_{\text{total}} = 15$ ) stayed immobile for more than half of the 15 minutes of the tests (Table 2). The other 20% indicates that the insect was moving in the cage with the predator for more than half of the test period. The three insects that were ingested by the Green frog are included in the 20%.

The Green frog is the only predator which has attacked and killed the nymphs of *S. sipyhus* and it did so in the three tests. In the first test, the Green frog needed only one attack before killing the prey (50 seconds after the insect was introduced inside of the cage). In the second and third tests, the Green frog needed more attacks (three in each case) before killing the prey. The time of the attacks were identical for the second and third tests. The first attack came after only three seconds after the introduction followed by the second and third attack at four and five seconds from the introduction of the nymph inside of the cage. The attacks were timed using a slow motion video recording.

The position of the insects in the glass cages with the predators were recorded and listed in Table 3 and Table 4. As observed in the TPPBR, about 80% of the insects stayed in a state of immobility for more than half of the period of the tests. The glass walls of the tanks used for the tests seemed to have been preferred for the immobile position of the insects over the tank floor. The insects exhibited the immobile position in both the higher and the lower portions of the glass walls at about the same frequency. The body of the insects in the immobile position was always at an angle smaller than 90° from the vertical (the head of the insect being always higher than the abdomen).



Position	Occurrence	Frequency
Cage floor	2	0.12
Upper half of glass wall	7	0.41
Lower half of glass wall	6	0.35
Halfway between wall and floor	2	0.12

**Table 3.** Position of the insect inside of the glass tank during immobility (all tests combined).

Angle from vertical	Occurrence	Frequency
0-5°	9	0.69
6-45°	2	0.15
46-90°	2	0.15
> 90°	0	0.00

**Table 4.** Angle of the insect's body when in the immobile position.

Another type of observation was recorded when the predators came within 5cm of the insect. This occurred five times (excluding the three times that the nymphs were eaten) and the results show that the insects, which were in a state of immobility every time, did not move at all from their position even if the predator moved closer for four of the five times. In the other instance, the insect moved away from the predator as soon as it got within 5cm. Three times the predator touched the insect accidentally and that created a movement of the insect away from the predator. The predators did not seem to be stimulated by the movement of the insects when they touched them.

One might ask if the size of the predator influenced the movement of the insects inside of the cage during the tests. Of all the tests with the Bullfrogs, two types of behaviour were observed: an immobile position was maintained by the insect for 95.8% of the total duration of the tests with the Bullfrogs, the other 4.2% represented a moving behaviour by the insect (which was mostly when the insect was first introduced in the cage). The results observed with the insects confronted with the American toad were almost identical as 96.0% of the total time spent by the insect was in a state of immobility. The Bullfrogs and the American toad used in this experiment were the two species of predators with the wider difference in body mass suggesting that the behaviour of the insects was not influenced by the size of the predators at this level. No case of autotomy was recorded in any of the tests.

To clarify the reasons why four out of the five predators used did not attack the nymphs of *S. sipylus*, four subsequent tests were done using different prey. In table 5 we can see that all of the predators ate at least one cricket including the treated crickets. The treatment with the chemical secretions of *S. sipylus* did not seem to keep the predators from eating the crickets as three out of five predators attacked them. It is important to notice that the dead crickets were never attacked. Only the Green frog attacked the specimen of stick insect presented to it which is consistent with the previous results.

Predators	Live crickets	Dead crickets	Treated crickets	<i>Bacteria</i> sp.
Green frog	X	-	X	X
American toad	X	-	-	-
Bullfrog 1 (female)	-	-	X	-
Bullfrog 2 (male)	X	-	-	-
Bullfrog 3 (male)	X	-	X	-

**Table 5.** Prey attacked by the predators (X) in the subsequent tests.

## Discussion

The results of the FPPBR show a bias towards the nymphs of *S. sipylus* being rejected both when moving and in a state of immobility, which is similar to the results found by Carlberg (1986). In the majority of the cases, the nymphs of *S. sipylus* walked for a few seconds after being introduced inside the cage with the predator. This behaviour could probably be explained by the fact that the insects were somewhat stressed by the movement from one environment (rearing cage) to another (test cage) by hand. Even if 87% of the insects moved for a few seconds after their insertion, the predators did not seem to be stimulated visually by this movement (except for the Green frog).

Keeping in mind that the amphibian predators used in this study were fed no food for the two days preceding the tests, one might wonder why only one out of the five predators ate the nymphs. With the use of sensitive visual detector cells, amphibians are able to evade oncoming predators and catch fast moving prey (Mitchell, Mutchmor & Dolphin, 1988). Theoretically, the initial movement by the nymphs should have stimulated the predators to attack. However, the results show otherwise which suggests that something stopped the amphibian predators from attacking the insects presented to them. It was first hypothesized that the chemical defence was effective against amphibian predators but the results obtained from the test with the treated crickets show otherwise. In fact, the three predators which attacked the treated crickets also ate them. If the chemical defence was noxious or repelling, the predators would have rejected the prey but the presence of the secretion of *S. sipylus* on the bodies of the crickets did not seem to stop the predators from eating them, therefore, the initial hypothesis that the chemical defence of *S. sipylus* has a strong repelling effect on the amphibian predators is ruled out. All of the predators ate at least one cricket proving that they were hungry.

Because none of the dead crickets were attacked, we can strongly suggest that immobile behaviour exhibited by prey such as *S. sipylus* would be a great adaptive value against potential attacks from amphibian predators. The fact that all the predators attacked crickets in at least one of the tests show that these predators associate the shape and the behaviour of the crickets with food. On the other hand, the predators did not associate the stick insects with food. In the wild, these North American species of amphibians do not come in contact with stick insects often because only a few rare species exist in their range. From the results of this study, we feel that it is more a combination of behaviour (immobility or vegetation mimicry) and unusual shape to the predators that kept the nymphs of *S. sipylus* from being attacked and eaten.

The reason why the Green frog ate the nymphs is still unknown. We could suspect that the Green frog is a more aggressive species than the others but it could also be attributed to a more aggressive individual of that species. Another way of explaining the reason why the green frog ate all three nymphs in the three tests is by assuming trial and error. The first attack by the green frog in the first test came 50 seconds after introduction. The nymph had moved a little for the first few seconds of the introduction and then stayed in a state of immobility on one of the glass walls until it started to move again towards the motionless green frog (after about 40 seconds). The attack came only after the nymph touched the green frog with its antenna and then with one of its front legs. If the insect had stayed in a state of immobility for the rest of the experiment, it can be hypothesized by the behaviour of the other predators that the Green frog would not have attacked the nymph. For the green frog, the drive to feed on the nymph probably overcame the unusual shape of the insect especially after the insect touched the frog. The result was that the green frog attacked and ate the insect. After that first successful trial, the green frog learned that the nymph was good to eat and this would explain the very fast attacks on the nymphs for the subsequent two tests. More testing with a larger sample is necessary in order to answer all these questions. When comparing the TPPBR, a definite bias towards the state of immobility ( $M^*$ ; 80% of times,  $N_{total} = 15$ ) and the rejection of the non moving prey ( $M^*E^*$ ; 100%) was observed. These results are also very similar to the ones obtained by Carlberg (1986) which shows that the defence strategy of the nymphs is usually the same, independent of the kind of predator (rodent or amphibian) it is facing.

The position of the immobile body of the nymphs was recorded; this revealed a preference for a vertical position (69% within 5° from the vertical,  $N=13$ ) on one of the glass walls (76%,  $N=17$ ). This defence behaviour is certainly advantageous for this insect which can make it look like a part of the vegetation.

The nymphs of *S. sipyilus* did not move (80% of times,  $N=5$ ) away from the predators even if the predators moved within 5cm of them. This suggests that it is advantageous for the insects to stay immobile and thus not to create a visual stimulation. It could also be disadvantageous because being so well disguised, the insects could potentially be stepped on by the predators causing injury or death. No case of autotomy occurred in this study which agrees with the low autotomy frequencies found by Carlberg (1981b, 1986).

According to Carlberg (1986) *S. sipyilus* is a more or less ground living insect which is exposed to a large number of different predators, e.g. other insects, small mammals, lizards, frogs and birds in its natural habitat. With a combination of defence mechanisms such as grass mimicry and chemical secretion, we can say that this species of stick insect is very well adapted against both rodents (Carlberg, 1986) and amphibian predators.

## Acknowledgments

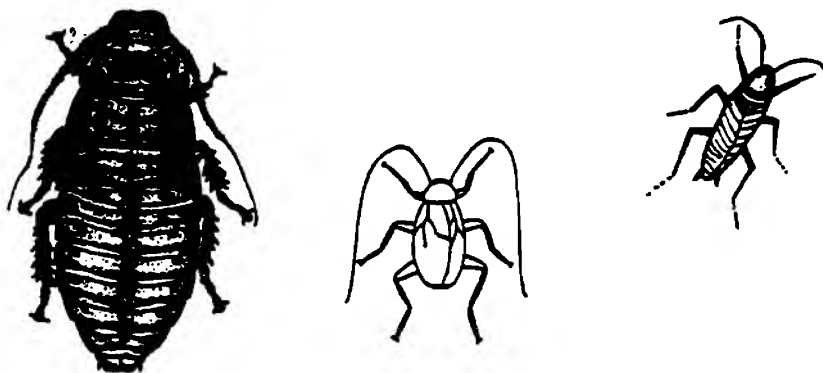
Many thanks to Dr. V.R. Vickery, Emeritus Curator of the Lyman Entomological Museum, for a critical reading of the manuscript. Also thanks to the Ecomuseum for providing us with the amphibians for the tests and the Insectarium for the *S. sipyilus* nymphs.

## References

- Browaeys-Poly, E. (1973) *Contribution à l'étude du développement et de la régénération de l'aile métathoracique chez le phasme Sipyloidea sipyilus Westwood (Insecte Cheleutoptère)*. Ph.D. Thesis Univ. Sc. Tech. Lille, France.
- Redtenbacher, J. (1908) *Die Insektenfamilie der Phasmiden*. 3. Leipzig.
- Carlberg, U. (1981a) Postembryonic Development in *Sipyloidea sipyilus* (Westwood). *Zoologische Garten (Leipzig)*, N.F. 51: 382-384.
- Carlberg, U. (1981b) An Analysis of the Secondary Defence Reactions in Stick Insects (Phasmida). *Biologisches Zentralblatt*, 100: 295-303.

- Carlberg, U. (1981c) Defensive Behaviour in Females of the Stick Insect *Sipyloidea sipylus* (Westwood). *Zoologischer Anzeiger*, 207: 177-180.
- Carlberg, U. (1985a) Chemical Defence in *Anisomorpha buprestoides* (Houttyn in Stoll) (Insecta: Phasmida). *Zoologischer Anzeiger*, 215: 177-188.
- Carlberg, U. (1985b) Chemical defence in *Extatasoma tiaratum* (MacLeay) (Insecta: Phasmida). *Zoologischer Anzeiger*, 214: 185-192.
- Carlberg, U. (1985c) Secondary defence in *Carausius morosus* (de Sinéty) (Insecta: Phasmida). *Zoologischer Anzeiger*, 215: 373-384.
- Carlberg, U. (1986) Chemical Defence in *Sipyloidea sipylus* (Westwood) (Insecta: Phasmida). *Zoologischer Anzeiger*, 217: 31-38.
- Carlberg, U. (1987) Postembryonic Ontogeny in *Sipyloidea sipylus* (Westwood). *Zoologische Jahrbucher Anatomie*, 115: 273-279.
- Carlberg, U. (1989) Aspects of the defensive behaviour of *Eurycantha calcarata* Lucas females and the evolution of scorpion mimicry in the Phasmida (Insecta). *Biologisches Zentralblatt*, 108: 257-262.
- Chopard, L. (1954) Sur la présence à Madagascar d'un Phasmide de la famille *Necrosiidae*. *Bulletin de la Société Entomologique de France*, 59: 140-141.
- Mitchell, L.G., Mutchmor, J.A., & Dolphin, W.D. (1988) *Zoology*. Benjamin/Cummings Publishing Company Inc. Ontario. pp. 739-740.
- Rabozzi, M.L. & Dazzini, M.V. (1972) Ricerche sulle glandole del protacace di *Sipyloidea sipylus* Westwood. (Phasmida). *Bolletino Societa Entomologica Italiana*, 104: 50-57.
- Robinson, M.H. (1969) The defensive behavior of some orthopteroid insects from Panama. *Transactions of the Royal Entomological Society of London*, 121: 281-303.
- Shiraki, T. (1935) Orthoptera of the Japanese Empire (Part IV) Phasmidae. *Memoirs, Faculty of Science and Agriculture. Taihoku Imperial University. Formosa. Japan*, 14: 61-88.
- Urvoy, J. (1969) Contribution à l'étude du dimorphisme sexuel chez le mâle adulte de phasme *Sipyloidea sipylus* W. *Bulletin de la Société Scientifique de Bretagne*, 44: 101-104.
- Westwood, J.O. (1859) *Catalogue of Orthopterous Insects in the Collection of the British Museum, Part I. Phasmida*. London.
- Yasumatsu, K. (1946) Some analyses on the growth of insects, with special reference to a phasmid, *Phraoras kumamotoensis* Shiraki (Orthoptera). *Journal of the Department of Agriculture. Kyusu Imperial University*, 8: 1-579.

## COCKROACHES



The Blattodea Culture Group produces a Newsletter for people interested in culturing cockroaches.

For further information contact: The Blattodea Culture Group, c/o Adrian Durkin, 8 Foley Road, Pedmore, Stourbridge, West Midlands, DY9 0RT, U.K.



# Changes of taxonomy in giant stick-insects.

Paul D. Brock, "Papillon", 40 Thorndike Road, Slough, SL2 1SR, UK.

## Abstract

The genus *Tirachoidea* Brunner von Wattenwyl is confirmed as a synonym of *Pharnacia* Stål, having been listed as a separate genus from 1893-1908 and since 1923. Listings of species are given, following the transfer of several species formerly in the genus *Pharnacia*, mainly to the genus *Phobaeticus* Brunner von Wattenwyl; for which for type species of *Phobaeticus sobrinus* has been selected. As a result of these significant taxonomic changes, affecting some of the longest species in the world, an amendment to keys to tribes of the subfamily Phasmatinae is proposed.

## Key words

Phasmida, *Pharnacia*, *Tirachoidea*, *Phobaeticus*, Taxonomy.

## Introduction

I originally received dead specimens and eggs of a species from Marinduque Island, Philippines via Mr Helmut Probst (Germany) in 1990, which I identified as *Pharnacia ponderosa* Stål, the type species of the genus *Pharnacia* Stål. It was apparent that these closely matched the adult morphology and egg structure of *Tirachoidea cantori* (Westwood, 1859) and, following research on a number of related species, by checking type material at several Museums, in addition to making a full review of the literature, I am now proposing a restructure of these genera by:

- i) confirming Redtenbacher's treatment (1908) of *Tirachoidea* Brunner von Wattenwyl, i.e. listing it as a synonym of *Pharnacia* (but for a different reason).
  - ii) transferring several *Pharnacia* species to the genus *Phobaeticus* Brunner von Wattenwyl, for which the type species *Phobaeticus sobrinus* Brunner von Wattenwyl, 1907 is designated in this work (along with a lectotype). As a result of this change, the genus *Phobaeticus* now includes species with winged or wingless males; females are always wingless.
  - iii) transferring *Phobaeticus sumatranus* Brunner von Wattenwyl to *Pharnacia*, due to an error in its original placement.
  - iv) amending keys dealing with tribes of the subfamily Phasmatinae.
- The changes are as used in my book on Malaysian phasmids (in press).

## Discussion on the genera *Pharnacia*, *Tirachoidea* and *Phobaeticus*

Following Brunner von Wattenwyl's splitting of the genus *Pharnacia* in 1893, when he transferred four species to his new genus *Tirachoidea*, authors have treated the genera as separate until publication of Brunner von Wattenwyl & Redtenbacher's monograph (1906-1908). The final section, published by Redtenbacher (1908), listed *Tirachoidea* as a synonym of *Pharnacia*, presumably because Redtenbacher considered that they belonged to the same genus. His key separates the first four more robust species (in the female) which includes the type species of *Tirachoidea*: *T. cantori* (Westwood), from much more elongate species (in the female). In his critical assessment of the monograph, Karny (1923: 240) returned the first four species mentioned by Redtenbacher to *Tirachoidea*, where they have remained until now.

Whilst I confirm Redtenbacher's synonymy, the reasoning is different. *Tirachoidea* is a synonym of *Pharnacia* on the basis that *T. cantori* belongs to the same genus as *Pharnacia ponderosa* Stål, the type species of *Pharnacia*. Redtenbacher's key to species listed *ponderosa* as "species uncertain", possibly because he had not examined the species; however, Karny was correct in splitting up Redtenbacher's treatment of *Pharnacia*, as they differ in adult morphology and egg structure, although he did not identify the link between *cantori* and *ponderosa*. The elongate species formerly in the genus *Pharnacia* are transferred

to *Phobaeticus*.

*Phobaeticus* is currently separated from *Pharnacia* because males are wingless in *Phobaeticus*, but winged in *Pharnacia*. Hence, where only females of *Phobaeticus* were described by Brunner von Wattenwyl, once males were traced, they could be transferred to *Pharnacia* (if winged) e.g. Bragg (1995) transferred the largest species in the world *Phobaeticus kirbyi* Brunner von Wattenwyl on this basis.

### The tribes of the subfamily Phasmatinae

*Phobaeticus* previously belonged to the tribe Baculini and *Pharnacia* (and its synonym *Tirachoidea*) to the tribe Pharnaciini, with the distinction between the two tribes relating to whether both sexes are completely wingless (Baculini), or winged in the male only (Pharnaciini). *Phobaeticus* should now be included in the Pharnaciini and marked as an exception to the current division i.e. it now includes males which are winged or wingless. A key to distinguish *Pharnacia* and *Phobaeticus* is given below:

1. Back of head rounded or elevated; often with two swollen tubercles. Males with large hind wings, all legs very spiny. Females of robust appearance with broadened thorax, males slender. . . . . *Pharnacia*
- Back of head neither raised or swollen. Hind wings in male either absent, large or reduced. Femora very serrate, particularly fore femora. Both sexes very elongate, female not robust. . . . . *Phobaeticus*

### Check-list of species

The listings are in alphabetical order within each genus, where I consider that the species are valid, although information on type specimens may be incomplete i.e. data may be fuller once all type material has been examined. The listings do not include all references to species made in the literature, only significant areas, including synonyms which are listed beneath each species, with relevant comments where necessary. The following changes to generic placement were not included in my Catalogue of Malaysian species (1996), as I was not able to check type material in MCSN and ANSP until the second half of 1995.

Museums and collections in which type material is located are abbreviated as follows. The abbreviations follow those of Arnett *et al.* (1993):

ANSP	Academy of Natural Sciences, Philadelphia, U.S.A.
BMNH	The Natural History Museum, London, England.
HNHM	Hungarian Natural History Museum, Budapest, Hungary.
ISNB	Institut Royal des Sciences Naturelles de Belgique, Brussels, Belgium.
MCSN	Museo Civico di Storia Naturale "Giacomo Doria", Genoa, Italy.
MHNG	Museum d'Histoire Naturelle, Geneva, Switzerland.
MNHN	Museum National d'Histoire Naturelle, Paris, France.
NHMB	Naturhistorisches Museum, Basel, Switzerland.
NHMW	Naturhistorisches Museum Wien, Wien (Vienna), Austria.
NHRS	Naturhistoriska Riksmuseet, Stockholm, Sweden.
NZSI	National Zoological Survey of India, Calcutta, India.
OXUM	University Museum, Oxford, England.
SMNS	Staatliches Museum für Naturkunde, Stuttgart, Germany.
ZMAS	Zoological Museum, Academy of Science, St. Petersburg, Russia.
ZMHB	Museum für Naturkunde der Humboldt Universität zu Berlin, Berlin, Germany.
ZMUH	Zoologisches Institut und Zoologisches Museum, Universität Hamburg, Hamburg, Germany.

***Pharnacia* Stål, 1877**

*Pharnacia* Stål, 1877: 40. Type species: *Pharnacia ponderosa* Stål, 1877. (Designated by Kirby, 1904: 359, if there was any doubt concerning Stål's intentions). It may be considered that Stål, by listing *ponderosa* as No.1 for his new genus, intended it to be the type. However, this is not clear, as he also linked his new genus with his *Phryganistria* Div.a (1875: 63), which included one species *Phryganistria acanthopus* (Burmeister) described as *Bacteria acanthopus* by Burmeister, 1838: 565, but now considered a synonym of *Phobaeticus serratipes* (Gray).

*Tirachoidea* Brunner von Wattenwyl, 1893: 83. Synonymised by Redtenbacher, 1908: 449. Type species: *Tirachoidea cantori* (Westwood) [*Phibalosoma cantori* Westwood, 1859: 74, pl. 37.1 (♂) & 38.1 (♀)], designated by Rehn, 1904: 70.

***Pharnacia annamallayanum* (Wood-Mason)**

*Phibalosoma annamallayanum* Wood-Mason, 1877a: 161. Syntypes: 1♀, S. India, Annamallay forests, coll. R.C. Beddome (in alcohol, presumed NZSI); 1♀, India, Travancore Hills coll. F. Day (very mutilated. Presumed NZSI).

*Phibalosoma annamallayanum* Wood-Mason, 1877b: 346, pl. 3.3 (♀). [misspelling].

*Pharnacia annamallayanum* (Wood-Mason); Kirby, 1904: 359.

***Pharnacia biceps* Redtenbacher**

*Pharnacia biceps* Redtenbacher, 1908: 451. Syntypes: 1♀, India, Assam (SMNS); 1♂, 2♀♀ Vietnam (MNHN) [examined]; Java (MHNG; HNHN - lost in fire; ZMHB; NHMW, 861; ISNB ?; MNHN; ZMUH; ZMAS). Hennemann *et al.* (1995: 437) listed the Assam ♀ in SMNS as a holotype, in error.

*Tirachoidea biceps* (Redtenbacher); Karny, 1923: 240.

***Pharnacia cantori* (Westwood)**

*Phibalosoma cantori* Westwood, 1859: 74, pl. 37.1 (♂) & 38.1 (♀). Lectotype ♂, Malaysia ["Malacca"] (OXUM, 621) [examined]; ♀ paralectotype, Malaysia (OXUM, 621) [examined].

*Tirachoidea cantori* (Westwood); Brunner von Wattenwyl, 1893: 83.

*Pharnacia cantori* (Westwood); Redtenbacher, 1908: 480.

***Pharnacia ponderosa* Stål**

*Pharnacia ponderosa* Stål, 1877: 40; Brock, 1992: 60 (rearing note), 13, fig. 10.34 (egg). Syntypes: 2♂♂, Philippines (NHRS) 1♂ examined.

***Pharnacia sumatranus* (Brunner von Wattenwyl)**

*Phobaeticus sumatranus* Brunner von Wattenwyl, 1907: 184. Syntypes: 1♀, Sumatra (MHNG) examined; ♀ (number of specimens not known) Sumatra, Indraviri (NHMB).

***Pharnacia westwoodi* (Wood-Mason)**

*Phibalosoma westwoodi* Wood-Mason, 1875: 216. Syntypes: 1♀, India, Nazeerah, coll. Foster (presumed NZSI); 1♀, India, Samaguting in Assam, coll. J. Butler (presumed NZSI).

*Tirachoidea westwoodi* (Wood-Mason); Kirby, 1904: 359; Qi & Lui, 1992: 250 [description of ♂ from China].

*Pharnacia westwoodi* (Wood-Mason); Redtenbacher, 1908: 451.



***Phobaeticus* Brunner von Wattenwyl, 1907**

*Phobaeticus* Brunner von Wattenwyl, 1907: 194. Type species [here designated]:  
*Phobaeticus sobrinus* Brunner von Wattenwyl, 1907.

***Phobaeticus annulatus* (Redtenbacher)**

*Pharnacia annulata* Redtenbacher, 1908: 451. Type(s) ♂, Borneo, Sampit (ZMHB).

***Phobaeticus beccarianus* Brunner von Wattenwyl**

*Phobaeticus beccarianus* Brunner von Wattenwyl, 1907: 185. Holotype ♀ (nymph):  
Sumatra, Mt. Singalang, vii.1878, coll. O. Beccari (MCSN) [examined].

***Phobaeticus enganensis* (Redtenbacher)**

*Pharnacia enganensis* Redtenbacher, 1908: 451. Lectotype [here designated]: ♂, Is. Engano,  
Bua Bua, v-vii.1891, coll. E. Modigliani (MCSN) [examined]; paralectotype ♂,  
same data (MCSN) [examined].

***Phobaeticus fruhstorferi* Brunner von Wattenwyl**

*Phobaeticus fruhstorferi* Brunner von Wattenwyl, 1907: 184. Syntypes: 1♀, Burma, Mt.  
Cariani, 1898, coll. D. Tornatore (MCSN) [examined]; 3♂♂, 1♀ (nymph), Vietnam,  
coll. Fruhstorfer (NHMW, 307) [examined].

This species was listed by Günther (1935: 124) as a synonym of *Phobaeticus grandis* (Rehn), which requires confirmation by critical examination of type material. The length of the Burmese ♀ is not given by Brunner von Wattenwyl, who only provided a measurement of 185mm for the ♀ nymph in NHMW. The ♀ from Burma is, in any event, very unlikely to represent the same species.

***Phobaeticus grandis* (Rehn)**

*Phryganistria grandis* Rehn, 1906: 279. Holotype ♂, Vietnam ["Tonkin"] (ANSP)  
[examined].

***Phobaeticus heros* (Redtenbacher)**

*Pharnacia heros* (Redtenbacher), 1908: 453. Syntypes: 1♀, Java, Tengger-Gebirge; 1♀, W.  
Java, 1893, coll. Sukabami (ZMUH); ♀ (number of specimens not known) Sumatra  
(coll. Mechel, present location unknown).

Whilst Weidner (1966: 231) listed the Tengger-Gebirge ♀ as holotype, and another ♀ as paratype, no holotype was selected by Redtenbacher and therefore it is likely that both specimens are syntypes.

***Phobaeticus hypharpax* (Westwood)**

*Phibalosoma hypharpax* Westwood, 1859: 75, pl. 13.6 (♂). Holotype ♂, Sri Lanka  
["Ceylon"] (BMNH) [examined].  
*Tirachioidea hypharpax* (Westwood); Brunner von Wattenwyl, 1893: 83.  
*Pharnacia hypharpax* (Westwood); Redtenbacher, 1908: 453.

***Phobaeticus incertus* Brunner von Wattenwyl**

*Phobaeticus incertus* Brunner von Wattenwyl, 1907: 185. Type(s) ♀, "Is. Banka (Mus  
Berol)".

Brunner von Wattenwyl's comments and species name imply doubt concerning the placement of this species, which I have not examined.

***Phobaeticus ingens* (Redtenbacher)**

*Pharnacia ingens* Redtenbacher, 1908: 453. Syntypes: 1♀, India, Malabar, Meppadi (MHNG, not included in my unpublished listing, but possibly overlooked); 1♀, Burma, Upper Tennasserim, Moolai to Moolat, 4000-6000ft [specimen referred to *Phibalosoma acanthopus* Burmeister by Wood-Mason, 1877: 161] (believed to be in NZSI).

***Phobaeticus kirbyi* Brunner von Wattenwyl**

*Phobaeticus kirbyi* Brunner von Wattenwyl, 1907: 185. Holotype ♀: Borneo (BMNH) [examined].

*Pharnacia kirbyi* (Brunner von Wattenwyl); Bragg, 1995: 26.

*Pharnacia serratipes*; Kirby, 1896: 448 (not Gray, 1835); misidentification of ♀, on which Brunner von Wattenwyl based his description of *Phobaeticus kirbyi*.

*Pharnacia maxima*; Kirby, 1904: 359 [in part].

*Pharnacia sagitta* Redtenbacher, 1908: 454, pl. XXII: 2(♀) (synonymised by Bragg, 1995: 27)

*Pharnacia pilicornis* Redtenbacher, 1908: 455 (synonymised with *Pharnacia sagitta* by Günther, 1932: 315)

***Phobaeticus maximus* (Bates)**

*Phibalosoma maximum* Bates, 1865: 341. Holotype ♀, Sumatra (OXUM, 622) [examined].

*Pharnacia maxima* (Bates); Kirby, 1904: 359. [Kirby also listed, as a synonym, the ♀ *P. serratipes* he described 1896: 450 - misidentification, see *Phobaeticus kirbyi*].

*Tirachoidea maxima* Bates; Karny, 1923: 240.

This species is very similar to *P. serratipes* and possibly synonymous, but I have yet to examine males from Sumatra.

***Phobaeticus nigricornis* (Redtenbacher)**

*Pharnacia nigricornis* Redtenbacher, 1908: 452. Type(s) ♂, Borneo (HNHM, lost in fire).

***Phobaeticus pinnipes* (Redtenbacher)**

*Pharnacia pinnipes* Redtenbacher, 1908: 452. Type(s) ♂, Malaysia, Selangor (MNHN, not traced).

***Phobaeticus rigidus* (Redtenbacher)**

*Pharnacia rigida* Redtenbacher, 1908: 453. Type(s) ♀, Sumatra, Mt. Battak (NHMW, 862).

***Phobaeticus semilunaris* (Redtenbacher)**

*Pharnacia semilunaris* Redtenbacher, 1908: 452. Holotype ♀, Java (NHMW, 859) [examined].

***Phobaeticus serratipes* (Gray)**

*Cladoxerus serratipes* Gray, 1835: 42. Holotype ♂, "Malabar" (BMNH) [examined].

*Phibalosoma serratipes* (Gray); Westwood, 1859: 75.

*Pharnacia serratipes* (Gray); Kirby, 1904: 359.

*Phasma* (*Bacteria*) *acanthopus* Burmeister, 1838: 565; synonymised by Kirby, 1904: 359. [Not *Pharnacia serratipes*; Kirby, 1896: 450 - misidentification, subsequently described as *Phobaeticus kirbyi* Brunner von Wattenwyl].

***Phobaeticus sichuanensis* Cai & Liu**

*Phobaeticus sichuanensis* Cai & Liu, 1993: 469. Holotype ♀, China, Sichuan Province, Zhongxian, 9.x.1989, coll. Zeng Lin & Hu Liancheng (Nankai Univ.); paratypes: 3♂♂, 2♀♀, same locality (Nankai Univ.).

***Phobaeticus sinetyi* Brunner von Wattenwyl**

*Phobaeticus sinetyi* Brunner von Wattenwyl, 1907: 184. Syntypes ♂ & ♀, India, Sembaganor, Pulney Hills, Madras. (MNHN, Pantel collection; one ♂ in collection marked: Kodikanel, coll. P. Décoly) [examined]. Possibly also syntype(s) in NHMW (NHMW, 308).

***Phobaeticus sobrinus* Brunner von Wattenwyl**

*Phobaeticus sobrinus* Brunner von Wattenwyl, 1907: 184, pl. VII. 1a (♂), 1b (♀). Lectotype [here designated: ♂, Sumatra, Si-Rambé, xii.1890-iii.1891, coll. E. Modigliani (MCSN) [examined]; paralectotype ♀, Is. Nias, 1897-1898, coll. U. Raap (MCSN) [examined]

***Phobaeticus spectabilis* (Redtenbacher)**

*Pharnacia spectabilis* Redtenbacher, 1908: 453. Type(s) ♀, Sri Lanka ["Ceylon"] (NHMW, 863).

***Phobaeticus tirachus* (Westwood)**

*Phibalosoma tirachus* Westwood, 1859: 75, pl. 37.3(♂). Holotype ♂, Malaysia ["Malacca"] (OXUM) [examined].

*Tirachoidea tirachus* (Westwood); Brunner von Wattenwyl, 1893: 83.

*Pharnacia tirachus* (Westwood); Redtenbacher, 1908: 452.

**Acknowledgements**

I would like to thank the following: Helmut Probst (Germany) for specimens and eggs of *ponderosa*; Judith Marshall (BMNH, London) for her constructive comments on my initial observations; Phil Bragg (Ilkeston, Derbys, UK.) for an extract from his Phasmid Database, for comparison with my paper records and to curators of the Museums mentioned, for allowing access to type material.

**References**

- Arnett, R.H., Samuelson, G.A. and Nishida, G.M. (1993) *The insect and spider collections of the world*. Flora & Fauna handbook No. 11, Sandhill Crane Press, Inc., Gainesville, U.S.A., 309pp.
- Bates, H.W. (1865) Descriptions of fifty-two new species of Phasmidae from the collection of Mr W. Wilson Saunders, with remarks on the family. *Transactions of the Linnean Society of London*, 25(1): 321-359, pl. 44-46.
- Bragg, P.E. (1995) The longest stick insect in the world, *Pharnacia kirbyi* (Brunner). *Entomologist*, 114(1): 26-30.
- Brock, P.D. (1992) *Rearing and studying stick and leaf-insects*. The Amateur Entomologists' Society, Feltham. 73pp.
- Brock, P.D. (1996) Catalogue of stick and leaf-insects (Insecta: Phasmida) associated with Peninsular Malaysia and Singapore. *Malayan Nature Journal*, 49: 83-102.
- Brock, P.D. (in press) *Stick and leaf-insects of Peninsular Malaysia and Singapore*. The Malaysian Nature Society.
- Brunner von Wattenwyl, K. (1893) Révision du système des Orthoptères et description des espèces rapportées par M. Léonardo Fea de Birmanie. *Annali del Museo Civico di Storia Naturale "G.Doria" Genova*, (2)13: 1-230.
- Brunner von Wattenwyl, K. (1907) *Die Insektenfamilie der Phasmiden*, 2: 181-338. Verlag Engelmann, Leipzig.
- Burmeister, H. (1838) *Handbuch der Entomologie*. Volume 2. T.C.F. Enslin, Berlin. 1050pp.
- Cai, B.L. & Liu, S.L. (1993) A new species of *Phobaeticus* from China (Phasmatodea: Phasmatidae). *Acta Entomologica Sinica*, 36(4): 469-471. [in Chinese, with English summary].
- Gray, G.R. (1835) *Synopsis of the species of insects belonging to the family of Phasmidae*. Longman, Rees, Orme,

Brown, Green and Longman, London. 48pp.

Günther, K. (1932) Phasmoiden des Kina Balu auf Borneo, aus dem Hamberger Zool. Museum. *Wiener Entomologische Zeitung*, 49(4): 313-320.

Günther, K. (1935) Ueber einige Phasmoiden aus der Sammlung des Herrn Dr. C. Willemse, Eijgelshoven. *Natuurhistorisch Maandblad Maastricht*, 24: 123-126 & 138-140.

Hennemann, F.H., Gehler, A.S. & Conle, O.V. (1995) Katalog des im Museum für Naturkunde in Stuttgart vorhandenen Typusmaterials der Insektenordnung Phasmatodea. *Entomologische Zeitschrift*, 105(2): 435-439.

Karny, H.H. (1923) Zur Nomenklatur der Phasmoiden. *Treubia*, 3(2): 230-242.

Kirby, W.F. (1896) On some new or rare Phasmidae in the collection of the British Museum. *Transactions of the Linnean Society of London*, (2)6(2): 447-475, pl. xxxix & xl.

Kirby, W.F. (1904) *A synonymic catalogue of Orthoptera. Euplexoptera, Cursoria, et Grescoria (Forficulidae, Hemimeridae, Blattidae, Mantidae, Phasmidae)*. 501pp. Longmans & Co, London.

Qi, Y.H. & Liu, S.L. (1992) A new record of *Tirachoides westwoodi* (Wood-Mason, 1875) from China and a description of its male (Phasmatodea: Phasmatidae). *Acta Zootaxonomica Sinica*, 17(2): 250-252.

Rehn, J.A.G. (1904) Studies in the orthopterous family Phasmidae. *Proceedings of the Academy of Natural Sciences of Philadelphia*, 56: 38-107.

Redtenbacher, J. (1908) *Die Insektenfamilie der Phasmiden*, 3: 339-576. Verlag Engelmann, Leipzig.

Rehn, J.A.G. (1906) Descriptions of five new species of Orthoptera from Tonkin. *Proceedings of the Academy of Natural Sciences of Philadelphia*, 58: 279-292.

Seow-Choen, F. (1995) The longest insect in the world. *The Malayan Naturalist*, 48(4): 12.

Stål, C. (1875) *Recensio Orthopterorum. Revue critique des Orthoptères décrits par Linné, de Geer et Thunberg*. Volume 3: 4-105. P.A. Norstedt & Söner, Stockholm.

Stål, C. (1877) Orthoptera nova ex Insulis Philippinis descripsit. *Öfversigt af Kongliga Vetenskaps-Akademiens Förhandlingar*, 34(10): 33-58.

Weidner, H. (1966) Die Entomologischen Sammlungen des Zoologischen Staatsinstituts und Zoologische Museums, Hamburg. Insecta III. *Mitteilungen aus dem Hamburgischen Zoologischen Museum und Institut*, 63: 209-264.

Westwood, J.O. (1859) *Catalogue of orthopterous insects in the collection of the British Museum. Part 1, Phasmidae*. British Museum, London. 184pp, 48 pls.

Wood-Mason, J. (1875) On new or little known species of Phasmidae, with a brief preliminary notice of the occurrence of a clasping apparatus in the males throughout the family. *Journal of the Asiatic Society of Bengal*, 44: 215-220.

Wood-Mason, J. (1877a) New and little known insects collected in Upper Tenasserim. *Journal of the Asiatic Society of Bengal*, 46(1): 161-163.

Wood-Mason, J. (1877b) Notes on Phasmidae. *Journal of the Asiatic Society of Bengal*, 46(4): 342-352, pl. 2-3.

# Redescriptions, synonyms, and distribution of two species of Lonchodinae from Borneo: *Lonchodes catori* Kirby and *Lonchodes hosei* (Kirby).

P.E. Bragg, 51 Longfield Lane, Ilkeston, Derbyshire, DE7 4DX, U.K.

## Abstract

*Lonchodes catori* Kirby and *Lonchodes hosei* (Kirby) are redescribed and distribution maps are given. Synonymies are listed for these two species and for the West Malaysian species *Lonchodes brevipes* Gray. The features distinguishing the closely related *L. brevipes* and *L. catori* are listed and illustrated. Lectotypes are selected for *L. catori* and *L. mindanaense* (Brunner). *Lonchodes mindanaense* is not a synonym of *L. hosei*. *Hermogenes cristatus* Kirby is a new junior synonym of *L. hosei*. *Dixippus jejunos* Brunner is a new junior synonym of *L. catori* Kirby. *Dixippus sodalis* Kirby is not a synonym of *L. brevipes*.

## Key words

Phasmida, *Lonchodes catori*, *L. brevipes*, *L. hosei*, *L. mindanaense*, Distribution, Borneo.

## Introduction

Günther (1932) published a revision of *Lonchodes*, in which he gave many new synonyms. Unfortunately he did not examine many of the type specimens and the paper appears to contain more wrong synonyms than correct ones. The genus presents problems because of the variation which occurs in the females and because of the strong sexual dimorphism. Most species have been inadequately described and most were not illustrated when they were described. Identification based on either of the available keys is unsatisfactory: Brunner's keys (1907) and descriptions are too brief, and Günther (1932) synonymised too many distinct species. I have checked several of the PSG cultures and type specimens of several species and can correct several synonyms. Below I give redescriptions of *L. catori* Kirby and *L. hosei* (Kirby), and details of all the relevant material which I have examined. I also include some details and a list of synonyms for *L. brevipes* (Gray), a species which is easily confused with *L. catori*. My own specimens have individual numbers prefixed by my initials and a hyphen; specimens in other museums are indicated by the use of standard codens as follows:

BMNH	British Museum of Natural History, London, U.K.
MCSN	Museo Civico de Storia Naturale "Giacomo Doria", Genova, Italy.
MHNG	Museum d'Histoire Naturelle, Geneva, Switzerland.
NHMB	Naturhistorisches Museum, Basel, Switzerland.
NHMW	Naturhistorisches Museum, Wien (Vienna), Austria.
OXUM	Oxford University Museum, Oxford, U.K.
RMNH	Nationaal Natuurhistorische Museum, Leiden, Netherlands.
SMSM	Sarawak Museum, Kuching, Sarawak.
SMTD	Staatliches Museum für Tierkunde, Dresden, Germany.

## *Lonchodes catori* Kirby, 1896

*Lonchodes catori* Kirby, 1896: 454; Brunner, 1907: 262. Lectotype [here selected] ♂ (BMNH, 95-140) Sabah, Sandakan, 28.ii.1893; Paralectotype ♀ nymph (BMNH, specimen not located) Sabah, Sandakan.

*Staelonchodes catori* (Kirby); Kirby, 1904: 318.

*Dixippus jejunos* Brunner, 1907: 278. Syntypes ♂♂, ♀♀ (NHMW, 523) Borneo; (NHMB) Sumatra, Indragiri. New synonym.

*Lonchodes jejunos* (Brunner); Hausleithner, 1989: 102, figs 2e-f (egg); Bragg, 1991a: 76-80; Bragg, 1991b: 18-21; Bragg, 1992: 300.

*Lonchodes uniformis*, Shelford, 1916: 153 [not Westwood, 1848], synonymised by Bragg 1992: 300.

[*Lonchodes uniformis* Westwood. Synonymised in error by Günther, 1935: 125]

## Material examined

### BORNEO

♀ (BMNH, 89-84) [acquired 1889]

### BRUNEI

Bandar Seri Begawan, Kota Batu

♀ (PEB-2216), ♂ (PEB-2217) 02.xi.1994



BRUNEI

Badas

2♀ (PEB-2213; PEB-2214), ♂ (PEB-2215) 31.x.1994  
unspecified area (probably Badas)  
♀ (PEB-1422), ♂ (PEB-1421) Bred by Mel Herbert, 1992  
3♀ (PEB-1460; PEB-1461; PEB-1821), 2♂ (PEB-1459;  
PEB-1495) reared, 1992  
eggs (PEB-1423) Laid by PEB-1422. 1992

SABAH

Kota Kinabalu

eggs (PEB-667; PEB-1080) Female not preserved. 01.viii.1990  
♀ (PEB-666) reared from PEB-1080 & PEB-667. 1990

Sandakan

♂ Lectotype of *L. catori* (BMNH, 95-140) 28.ii.1893

Ulu Dusun

♂ (BMNH, BM 1977-615) A. Lamb, 14.iv.1976

SARAWAK

locality not specified

♂, ♀ nymph (BMNH, 1900-117) Shelford [acquired 1900]

15km NE of Selangau

♀ (PEB-2226), ♂ (PEB-2227) 26.x.1994

22km SW of Selangau

♂ (PEB-2225) 26.x.1994

3km NE of Tatau

♂ (PEB-2219) 04.xi.1994

Bahagian Kuching

2♀ (PEB-1224; PEB-1230), ♂ (PEB-1235) reared 1989  
nymph (PEB-1350) viii.1989

Damai, 30m

♀ (PEB-657) Contained mermithid larvae. 28.xii.1987  
♀ (PEB-1226) Contained mermithid larvae. 28.xii.1987  
eggs (PEB-1234) laid by PEB-657 & PEB-1226, 28.xii.1987  
♀ nymph (PEB-1232) 28.xii.1987  
3♀ (PEB-1335; PEB-1336; PEB-1338), 2♂ (PEB-669;  
PEB-1237) 1st generation reared, 1988

SARAWAK

Bengoh

♀ (PEB-659) 29.vii.1989  
2♀ (PEB-1337; PEB-1341), ♂ (PEB-670) 31.vii.1989  
2♀ (PEB-658; PEB-1225), ♂ (PEB-668) ♀ nymph (PEB-1340)  
01.viii.1989

Kuching, Jalan Stampin Timur

♂ (PEB-1348) 17.viii.1989

Mt Santubong, 30m

♂ (PEB-1238) 17.viii.1989

Mt Santubong, 700m

♀ (PEB-1653), ♂ (PEB-1652) 11.viii.1992

Mt Santubong, 880m

♀ (PEB-1654) Mounted with eggs. 11.viii.1992

Mt Santubong, 50-300m

♀ (PEB-2221) Mounted with eggs. 21.x.1994

Niah NP

♀ (PEB-1631) Mounted with eggs, ♂ (PEB-1630) 16.viii.1992

Batu Niah

2♀ (BMNH, BM 1982-387) A. Harman, xi-xii.1980

2♀, ♂ (BMNH, BM 1982-387) A. Harman, xii.1980

Simunjan

♀ (PEB-629), 2♂ (PEB-628; PEB-630) 17.viii.1991  
eggs (PEB-633) Eggs from several females at this locality.  
17.viii.1991

Tarum

♀ (PEB-2218) Mounted with eggs. 25.x.1994

near Betong

♀ (PEB-2222), ♂ (PEB-2223) mating pair, 25.x.1994

♀ (PEB-2257), ♂ (PEB-2224) 25.x.1994

mixed stock (Western Sarawak)

7♀ (PEB-671; PEB-672; PEB-1227; PEB-1228; PEB-1229;  
PEB-1231; PEB-1339) 1990

5♂ (PEB-632; PEB-674; PEB-1011; PEB-1095; PEB-1236)  
1990

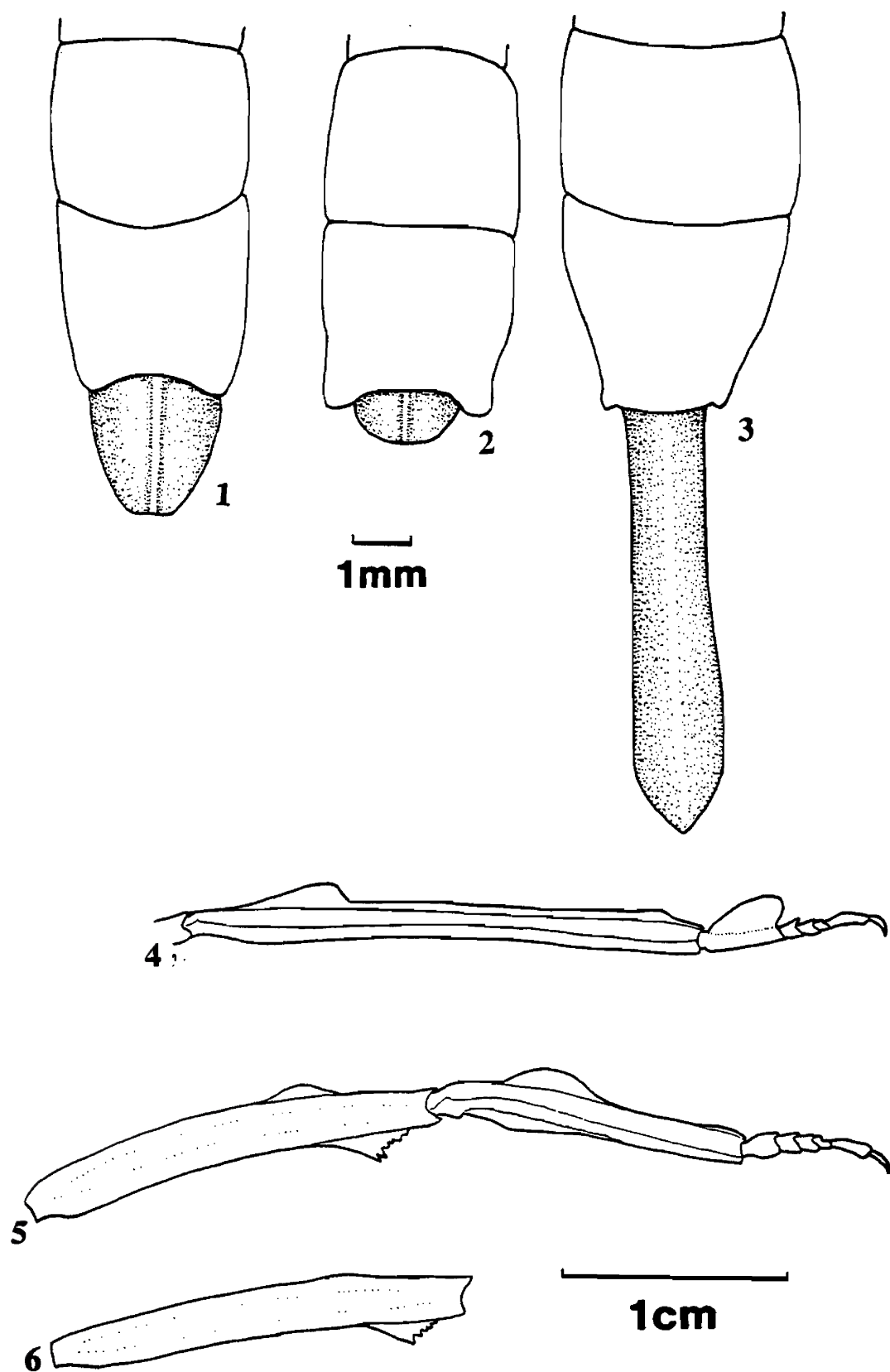
spermatophores (PEB-1233) from floor of cage, 1990

Female (Figures 2, 4-6, 8-9)

Head, body and legs uniformly mid brown, dark brown, or dark green-brown. In green-brown specimens the hind legs tend to be much greener than the rest. Head and thorax evenly granulose; abdominal terga evenly granulose at anterior, becoming sparingly and indistinctly granulose towards the posterior, abdominal sternites smooth, operculum setose. Femora and tibiae setose, particularly on the carinae; mid femora granulose. Body length 117-158mm.

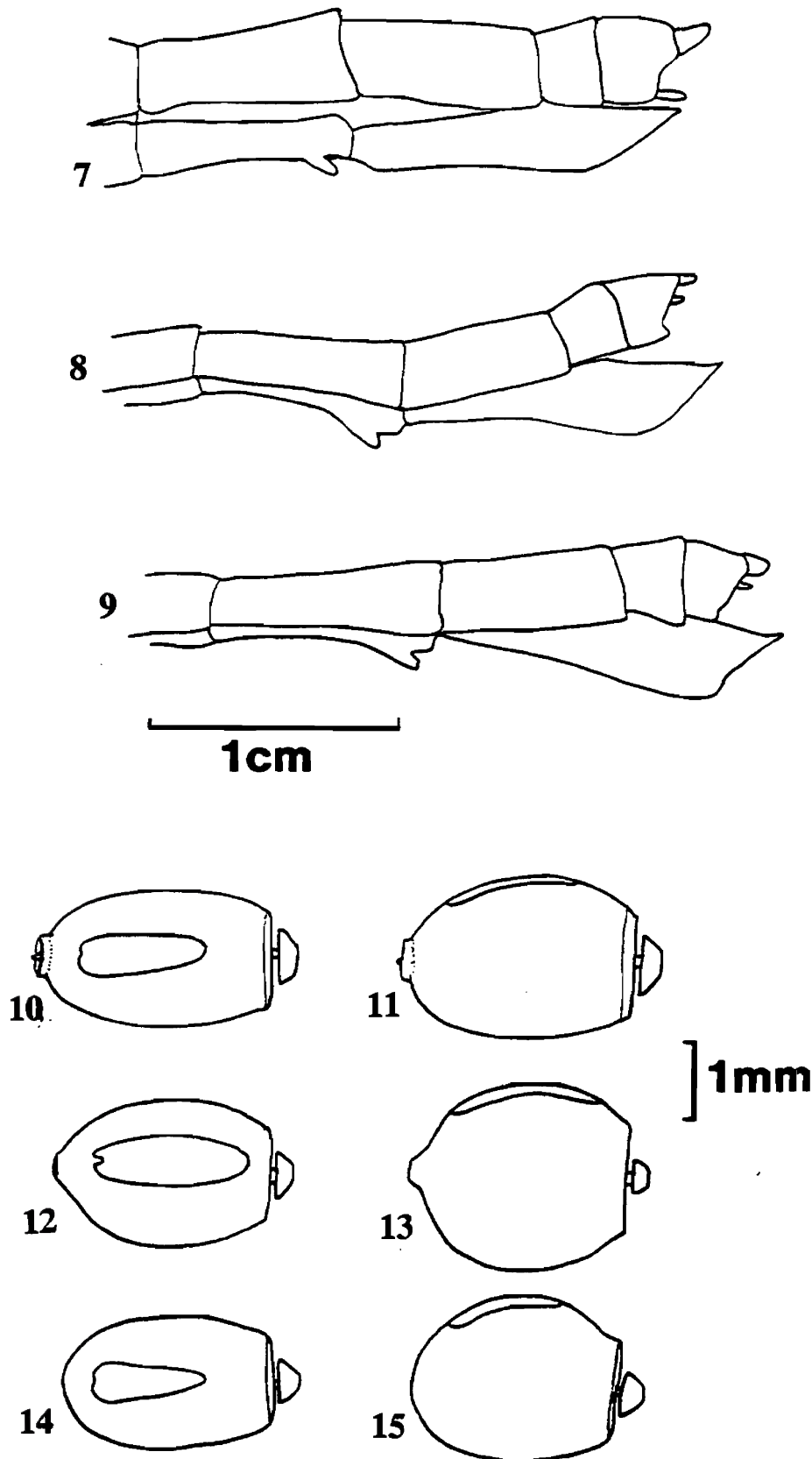
Antennae longer than the fore legs, with basal segment flattened and laterally dilated, second segment twice as thick as remainder. Head slightly longer than wide, with a very slight ridge between the eyes, sometimes with a minute pair of spines. Pronotum about one-and-a-third times longer than wide with a median transverse depression, a shallow longitudinal groove and a shallow groove just behind the anterior margin. Mesonotum long, widening only slightly until just before the leg joint where it widens and flattens; at this point the mesopleura project, increasing the body width to one-and-a-half times the width of the mesonotum. Metanotum of uniform width. Median segment slightly longer than wide; about one quarter of the length, and slightly narrower than the metanotum. Metapleura projecting slightly. Abdomen of similar width to the thorax, segments 2-8 roughly twice as long as wide, 8th slightly constricted in the middle, 9-10 about as long as wide. Anal segment with posterior margin slightly indented. Lamina supraanalis roughly semicircular, about twice as wide as long (figure 2). Operculum reaching to end of anal segment, scoop-shaped, with a slight ventral keel, apex rounded. Posterior of 7th sternite with a small conical, spine-like, praeopercular organ (figures 8 & 9). Cerci very short, slightly flattened.

Hind legs reaching just beyond the end of the 6th abdominal segment, mid legs almost to the end of the 3rd segment; middle femur not reaching the posterior of the median



**Figures 1-6.** 1-3. Apex of female's abdomen: 1, *L. brevipes*; 2, *L. catori*; 3, *L. everetti*; 4-6. *L. catori*: 4, Fore tibia and tarsus; 5-6, Middle femora.





**Figures 7-15.** Lateral views of apices of females' abdomens, and dorsal and lateral views of eggs: 7 & 10-11, *L. brevipes*; 8-9 & 12-15, *L. catori* (from two different localities).

segment. Fore femora compressed and incurving at the base; mid femora thickened, slightly arched, with a minute smooth lobe on the dorso-posterior carina which is variable in size (figures 5 & 6); hind femora straight and slender. All ventral carinae of femora, except ventro-anterior of fore femora, with an apical lobe which bears a few small spines, the lobes are largest on the mid femora. All tibiae with a distinct medio-ventral carina. Fore tibiae with ventro-medial carina forming a long straight lobe along the length of the tibia, the dorsal carinae unite to form a similar lobe which also bulges near the base of the tibia. Middle tibiae (figure 5) with dorsal carinae united on the basal half, forming a large rounded lobe; ventro-medial carinae with lobe on the basal half. Hind tibiae with all carinae distinct and not lobed. Fore tarsi with large rounded lobe on the basal tarsomere (figure 4). Fore and hind tarsi with 1st tarsomere about as long as 2-4 combined; mid tarsi with 1st tarsomere of similar size to 2-3.

#### **Male (Figure 17)**

Colour very variable: base colour usually greenish-brown or reddish-brown, frequently more or less uniformly coloured; a common variation is brown body with dark green stripe on mesothorax and metathorax and green legs, more rarely the body is green with joints of the thorax and legs red. Head, thorax (dorsally and ventrally), and middle femora granulose, abdomen smooth. Legs with all carinae setose. Body length 88-107mm.

Antennae longer than the fore legs, first two segments thicker than the rest. Head longer than wide, with a slight ridge and two very small spines between the eyes. Pronotum as in female. Anterior margin of mesonotum slightly wider than the middle, posterior widened and flattened. Mesopleura protrude at the leg joint, at this point the body is two-and-a-half times wider than the middle of the mesonotum. Metanotum arched, slightly dilated at each end. Metapleura projecting at leg joints. Metanotum four times longer than median segment. Abdominal segments 2-7 about three times longer than wide, 8-10 much shorter than 2-7; 7th widening slightly at posterior. Segment 8 widening, and 9 narrowing, together forming a diamond shape which is twice as wide as the rest of the abdomen. Anal segment divided longitudinally, viewed from the side the dorsal surface is without any concave section (figure 17). Poculum with the ventral angle less than 90°, apex rounded. Cerci short, cylindrical.

Fore femora with base compressed and incurving, apex of ventro-posterior carina with one triangular lobe-like spine, ventro-anterior unarmed. Middle femur thickened and slightly arched, apex of both ventral carinae with a small lobe bearing 3-4 spines. Hind femur straight, slender, apices of ventral carinae each with 2-3 small spines. All tibiae without lobes or spines. Fore tarsi with lobe on basal tarsomere. Fore and hind tarsi with first tarsomere as long as combined length of 2-4, mid tarsi with first tarsomere only as long as 2-3.

#### **Egg (Figures 12-15)**

Capsule and operculum mid to dark brown, micropylar plate light brown or cream, occasionally the micropylar plate is surrounded by a blackened area, capitulum orange. Capsule ovoid, covered with minute pits; with or without a polar mound, if present it is very small and solid (without a central hollow). Micropylar plate almost oval, wider at polar end. Operculum flat. Typical length 2.8mm, height 2.3mm, width 1.9mm.

#### **Comments**

This species is extremely closely related to *Lonchodes brevipes* Gray, distinguishing the species is difficult. The males may be distinguished by the shape of the poculum which is

more angular in *brevipes*, and by the anal segment which does not have a concave dorsal edge and is not as slender as that of *brevipes*. The eggs of *brevipes* are clearly longer than high and have a large polar mound, those of *catori* are almost spherical and if a polar mound is present it is generally small (those from Kota Kinabalu, figures 12-13, are relatively large). Females of *brevipes* have an operculum which is more or less straight and lacks a distinct keel, the operculum of *catori* is deeper at the apex and often has a distinct keel; the lamina supraanalis of *catori* is never longer than wide, that of *brevipes* is longer than wide (in the few specimens examined); *brevipes* females are often more robust and the thorax is more dilated where the legs join.

The two BMNH specimens from the Sandakan district of Sabah (BM 95-140 & BM 1977-615) both have the same unusual colouring: green body with the head and legs orange and the thorax orange around the leg joints; Kirby's specimen has femora which are mainly green.

Although I have not examined Brunner's specimens of *jejusus* in detail, it is almost certain that the Bornean specimens are the same species; this may not be true for the Sumatran specimens.

### Distribution (Figure 26)

There are a considerable number of specimens in the Sarawak Museum which appear to be this species. These specimens are from Kuching, Matang, Matang Road, and two from Baram; I have not checked the identity of these specimens so they are not included on the distribution map. The distribution map shows only material which I have checked, most of this is material which I have personally collected. The species is clearly widespread in northern Borneo (figure 26) where most of my collecting has been done; it may be widespread in Kalimantan but I have only collected at three sites and did not find any *L. catori*.

### Cultures

Mainly as a result of collecting at a series of different sites along the length of Sarawak in 1994, three cultures (39, 119 and 129) on the Phasmid Study Group culture list were found to be the same species, two of these were previously misidentified as *L. uniformis* (PSG 39), and *L. validior* (PSG 129), the third culture was previously listed by the junior synonym *L. jejusus* (PSG 119). Culture 129 is from Brunei and is still in culture, as is culture 119 from western Sarawak; culture 39 from eastern Sarawak died out many years ago. Culture 39 was collected by Allan Harman from Niah in 1980 and died out in the mid 1980s. Culture 129 is based on material collected by Mel Herbert at Badas. Culture 119 is based on material collected by myself and various companions over several years, mainly from Bengoh, Mt Serapi, and Mt Santubong. This species feeds on bramble, eucalyptus, raspberry and rose.

### *Lonchodes brevipes* Gray, 1835

*Lonchodes brevipes* Gray, 1835: 19; Westwood, 1859: 36; Kirby, 1904: 321; Hausleithner, 1989, fig 2a (egg): 102; Hausleithner, 1991: 233; Seow-Choen et al., 1994a: 12, fig 6; Seow-Choen et al., 1994b: 394; Brock, 1996: 85. Holotype ♂ (BMNH, 40-30-3-712) India, Malabar.

*Lonchodes pterodactylus* Gray, 1835: 19; Synonymised by Westwood, 1859: 36; Günther, 1932b: 382. Syntypes ♀ (BMNH, 40-30-3-709), ♂ (BMNH, 40-30-3-712), Malabar.

*Prisomera pterodactylus* (Gray), Brunner, 1907: 288.

*Phasma* (*Bacteria*) *nodosum* (*sumatranum*) de Haan, 133, pl. 13.6 (♀). Synonymised (with *pterodactylus*) by Günther, 1932b: 382. Holotype ♀ (RMNH) Sumatra, Batang Singalang.

*Prisomera gestroi* Brunner, 1907: 289; Brock, 1996: 86 [Lectotype designation]. Lectotype ♀, Paralectotype ♂ (MCSN) Sumatra, Mentawai Island. Synonymised by Günther, 1932b: 382.

- Phasma (Lonchodes) uniforme* Westwood, 1848: 79, pl. 39.3. Holotype ♂ (OXUM, 571) Prince of Wales' Island, coll. D. Cantor. Synonymised by Brock, 1996: 86.
- Lonchodes uniformis* Westwood, Westwood, 1859: 37; Kirby, 1904: 321; Günther, 1932b: 382; Klante, 1960: 99, figs 8 (♂), 9 (♀); Hausleithner, 1989: 102, fig 2b (egg).
- Dixippus uniformis* (Westwood), Rehn, 1904: 42.
- Prisomera uniforme* (Westwood), Brunner, 1907: 288.
- Phasma (Bacteria) nodosum (sumatranum)* de Haan, 1842: 133, pl. 13.3. Synonymised (with *uniformis*) by Brunner, 1907: 288. Holotype ♀ (RMNH) Sumatra, Batang Singalang.
- Dixippus validior* Brunner, 1907: 279. Synonymised with *uniformis* by Günther, 1935: 125. Lectotype ♂, Paralectotypes 8♂♂, 12♀♀ (NHMW, 533) West Malaysia, Perak.
- Carausius validior* (Brunner); Brock, 1996: 86 [Lectotype designation].
- [*Dixippus jejunos* Brunner; Synonymised in error by Günther, 1935: 125; corrected by Bragg, 1992: 300.]
- [*Dixippus sodalis* Kirby, 1896: 459. Synonymised in error by Günther, 1932b: 382.]
- [*Lonchodes dispar* Bates, Synonymised in error by Günther, 1932b: 382, corrected by Bragg, 1992: 299.]

## Material examined

### WEST MALAYSIA

locality unknown (Original PSG culture)

♂ (PEB-1345), ♀ nymph (PEB-1342), ♂ nymph (PEB-1343) 1988  
3♀♀ (PEB-655; PEB-656; PEB-1344), ♂♂ (PEB-663; PEB-664;  
PEB-1346), eggs (PEB-665) 1989

Pahang, Tasik Chini

♀ (PEB-2237), ♂ (PEB-2236) 15.x.1994

Perak, 4 miles SW Tanjong Malim

♂ (BMNH, BM 1964-39) J.R. Piffet, 19.v.1959

## Comments

The female (figures 1 & 7) is very similar to *L. catori* but the lamina supraanalis is at least as long as wide (figure 1) but never as long as *L. everetti* Kirby (figure 3), and the operculum lacks a keel. The male is very similar to *L. catori* but anal segment when viewed laterally has a concave dorsal edge (Figure 16). Egg similar to *L. catori* but not as high or as wide, polar mound larger and with a central hollow (figures 10-11).

*Lonchodes brevipes* has been recorded from the river Mahakam in Borneo by Günther (1943: 153), but Günther regarded *jejunos* (= *catori*) and *brevipes* as synonymous so the specimens are probably *L. catori*. Hausleithner's (1991) record of a female from Ulu Dusun is probably a specimen of *L. catori* although I have not examined the material.

Examination of the type specimen of *Dixippus sodalis* Kirby shows that it is clearly a different species to *catori*, so Günther was wrong to synonymise these species.

## *Lonchodes hosei* (Kirby, 1896)

*Hermogenes hosei* Kirby, 1896: 457. pl. 40.1. Holotype ♀ (BMNH, 89-24) Sarawak, Baram district, coll. C. Hose.

*Hermagoras hosei* (Kirby); Kirby, 1904: 322.

*Prisomera hosei* (Kirby); Brunner, 1907: 286.

*Lonchodes hosei* (Kirby); Günther, 1932b: 376 [in part]; Hausleithner, 1984: fig 3a (♀), 4a (egg); Singy, 1988: 13, figs (♂, ♀♀, egg); Hausleithner, 1989: 102, fig 3e (egg); Hausleithner, 1991: 234, figs 6d, 11 (♂).

*Prisomera tuberculatum* Brunner, 1907: 287. Synonymised by Günther, 1932b: 376. Type(s): ♀ (MNHN) Mindanao.

*Prisomera palawanica* Carl, 1913: 30. Synonymised by Günther, 1932b: 376. Holotype ♀ (MHNG) Palawan.

*Prisomera morbosum* Brunner, 1907: 290. Syntype(s) ♂♂ (NHMW, 568) Sabah, Kinabalu; Listed as a possible synonym by Günther, 1932b: 376.

*Lonchodes hosei papuanas* n.ssp. Günther, 1930: 739. fig. 6 (♀). Holotype ♀ (Berlin) New Guinea, coll. Fruhstorfer.

*Hermogenes cristatus* Kirby, 1896: 457. Holotype ♀ (BMNH, 94-138) Sarawak, Baram district, C. Hose. New synonym

*Hermagoras cristatus* Kirby; Kirby, 1904: 322.

*Prisomera cristatum* (Kirby); Brunner: 289.

*Lonchodes cristatus* (Kirby); Günther, 1932b: 386.

[*Prisomera rusticum* Brunner; Synonymised in error by Günther, 1932b: 376 - Hausleithner, 1989: 102, shows the eggs are different]

[*Prisomera thoracicum* Brunner, 1907: 289. Synonymised by Günther, 1932b: 376 - in error according to Brock,

1996: 86.]

[*Prisomera mindanaense* Brunner, 1907: 286. Synonymised in error by Günther, 1932b: 376. Syntypes: ♂♂, ♀♀ (SMTD) Mindando].

[Not *Lonchodes hosei* Günther; 1932a: 69 - misidentified, see Günther 1943: 153.]

[Not *Lonchodes hosei* Günther, 1932b: 379 [in part], figs 9.3, 12.10, 12.14, 13.6 - misidentified, see Günther, 1943: 153.]

## Material examined

### NORTH BORNEO

locality not specified

♀ (RMNH) N. Borneo Expedition 1912, Mohari

### SABAH

Locality unknown (Original PSG stock)

♂ (PEB-661), eggs (PEB-662) Reared by P. Jennings, 1989

eggs (PEB-1123) Bred by R. Osbourne, pre-1985

♂ (PEB-1347) Reared by K. D'Hulster 1989

♀ (PEB-1731) Reared by M. Herbert, 1992

♂ (PEB-1432) Captive reared, 1992

Bettotan, nr Sandakan

18♂♂, 6♀♀ nymphs, 24♀♀ (RMNH) [various dates in] vii-viii.1927, C.B.K. & H.M.P. collection

♀, ♀ nymph (BMNH, BM1955-354) ex F.M.S. Museum, 25.vii.1927, C.B.K. & H.M.P. collection

♀ nymph (BMNH, BM1955-354) ex F.M.S. Museum, 27.vii.1927, C.B.K. & H.M.P. collection

♀ nymph (BMNH, BM1955-354) ex F.M.S. Museum, 10.viii.1927, C.B.K. & H.M.P. collection

♂ (BMNH, BM1955-354) ex F.M.S. Museum, 20.viii.1927, C.B.K. & H.M.P. collection

### SABAH

Sepilok Forest Reserve

♀ (PEB-1524; PEB-1525) 22.viii.1992

♂ (PEB-1522) 23.viii.1992

3♂♂ (PEB-1520; PEB-1521; PEB-1523), ♀ nymph (PEB-1526) 24.viii.1992

Mt Kinabalu NP, Poring Hot Springs, 450m

♀ (PEB-1685), ♂ (PEB-1686), eggs (PEB-1954) 21.viii.1992

Sepilok & Poring (mixed stock)

3♀♀ (PEB-2021; PEB-2022; PEB-2023), ♂ (PEB-2079), eggs (PEB-2115) 1st generation captive-reared, 1993

Tawau

♀ (PEB-2477), ♂ (PEB-2478) S. Mallet, 27.vi.1995

### SARAWAK

Bau, near Wind Cave

♀ (PEB-2246) Mounted with egg, 06.xi.1994

Niah NP, near Great Cave

♀ (PEB-2253) 28-10-1994

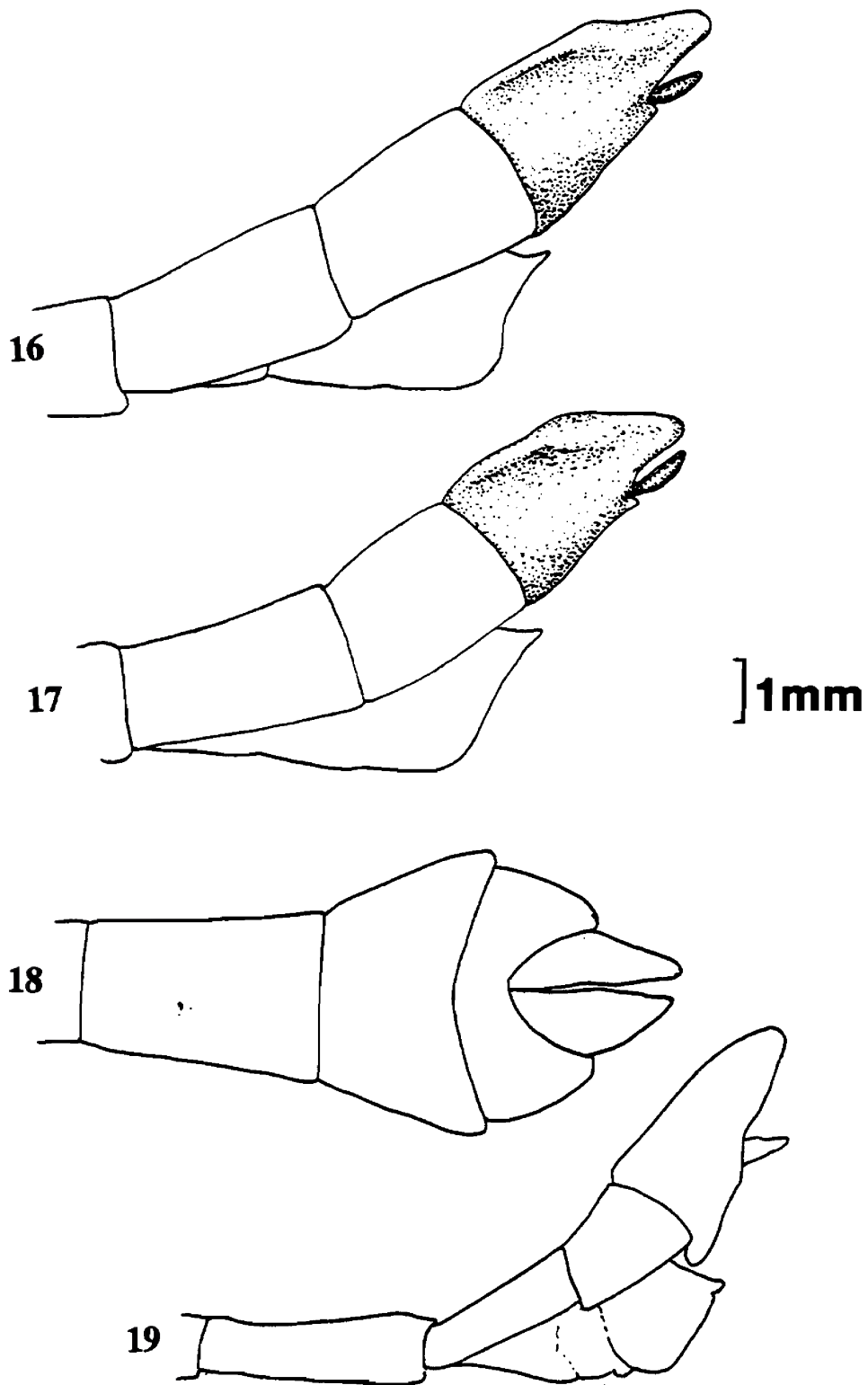
## Female (Figures 22-23)

Body coloration variable, base colour light brown to almost black; generally either dark with indistinct lighter blotches, or light brown with dark longitudinal stripes. Posterior surface of hind femur bright red or red-brown, rest of legs similar to base colour of body. Head, body and legs roughly granulose, and rugulose, some abdominal segments occasionally verrucose or lobed. Body length 110-139mm.

Antennae almost as long as the fore legs, basal segment flattened and dilated, second segment wider than remainder. Head rectangular, twice as long as wide. Pronotum one-and-a-third times longer than wide, with a median transverse groove. Mesonotum broader than pronotum, of almost uniform width, posterior only very slightly widened. Mesopleura projecting slightly. Metanotum of uniform width, three times longer than median segment. Median segment narrower than metanotum. Abdomen of almost uniform width, similar to thorax. Segments 2-7 of similar length, about two-and-a-half times longer than wide, 8 as long as wide, 9-10 shorter than wide. Segments 8-10 usually with a longitudinal carina. Posterior of 5th and anterior of 6th occasionally swollen and verrucose. Posterior of segments 1-8 occasionally with a pair of lobes, these specimens may also have a small lobe or swelling on the posterior of the mesonotum and metanotum. Lamina supraanalis variable, from small semicircle to pointed lobe three times longer than wide, apex may be bilobed. Operculum projecting beyond the anal segment, with a deep keel, deepest at the extremity and with a tuberculate and serrated apex. Cerci very short, usually hidden.

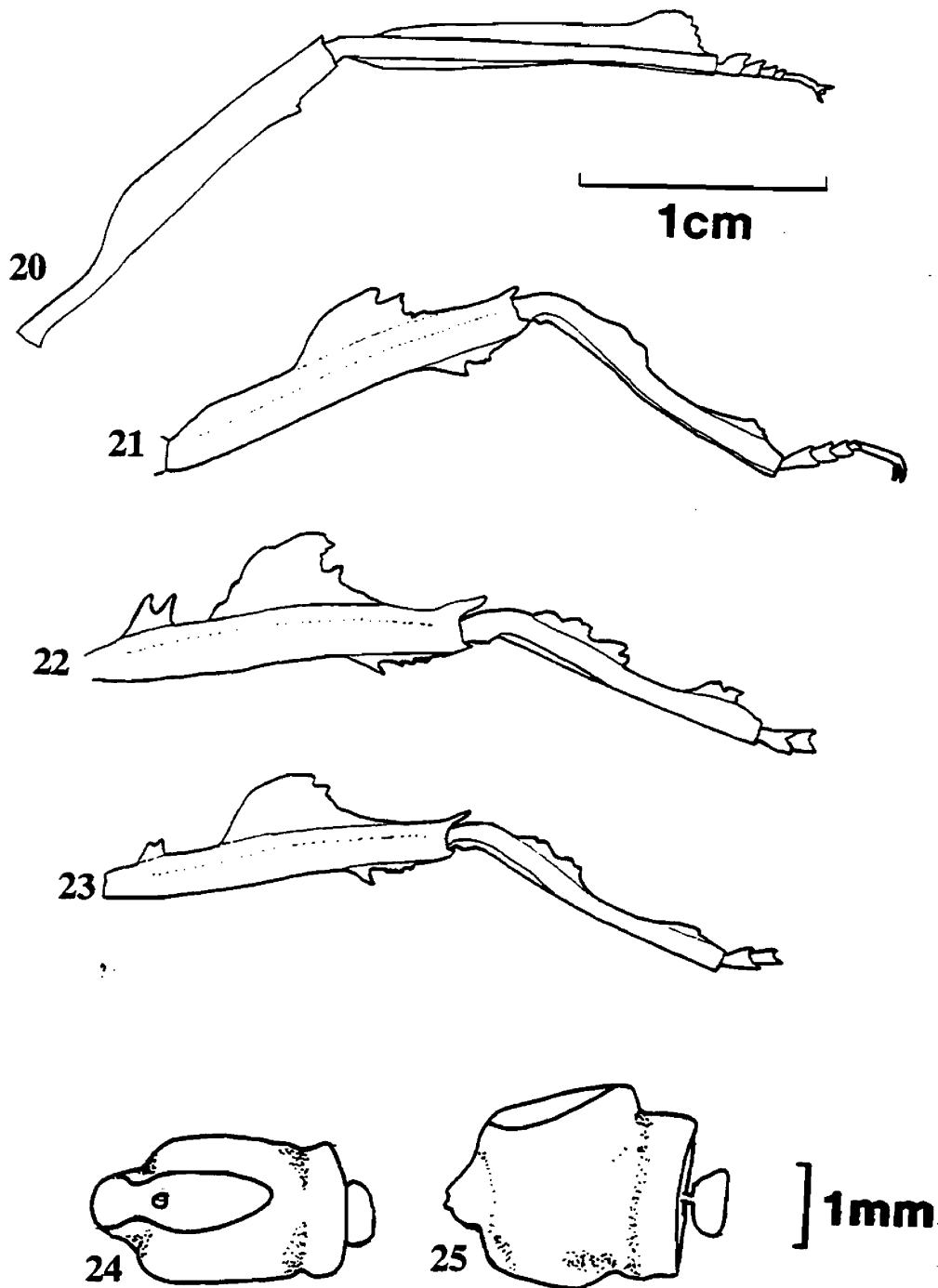
All femora and all tibiae with very distinct medio-ventral carinae. Apices of all femora with a blunt spine-like lobe over the joint with the tibia. Dorso-anterior carina of fore femur with irregular lobe, medio-ventral and ventro-posterior lobe-like, apex of ventro-posterior with a triangular spine-like lobe and 1-2 minute spines. Mid femur with dorsal carinae indistinct and more or less united, with two distinct lobes (figures 22-23), one small serrated lobe one third of the way along the femur, and one large serrated lobe two thirds of the way



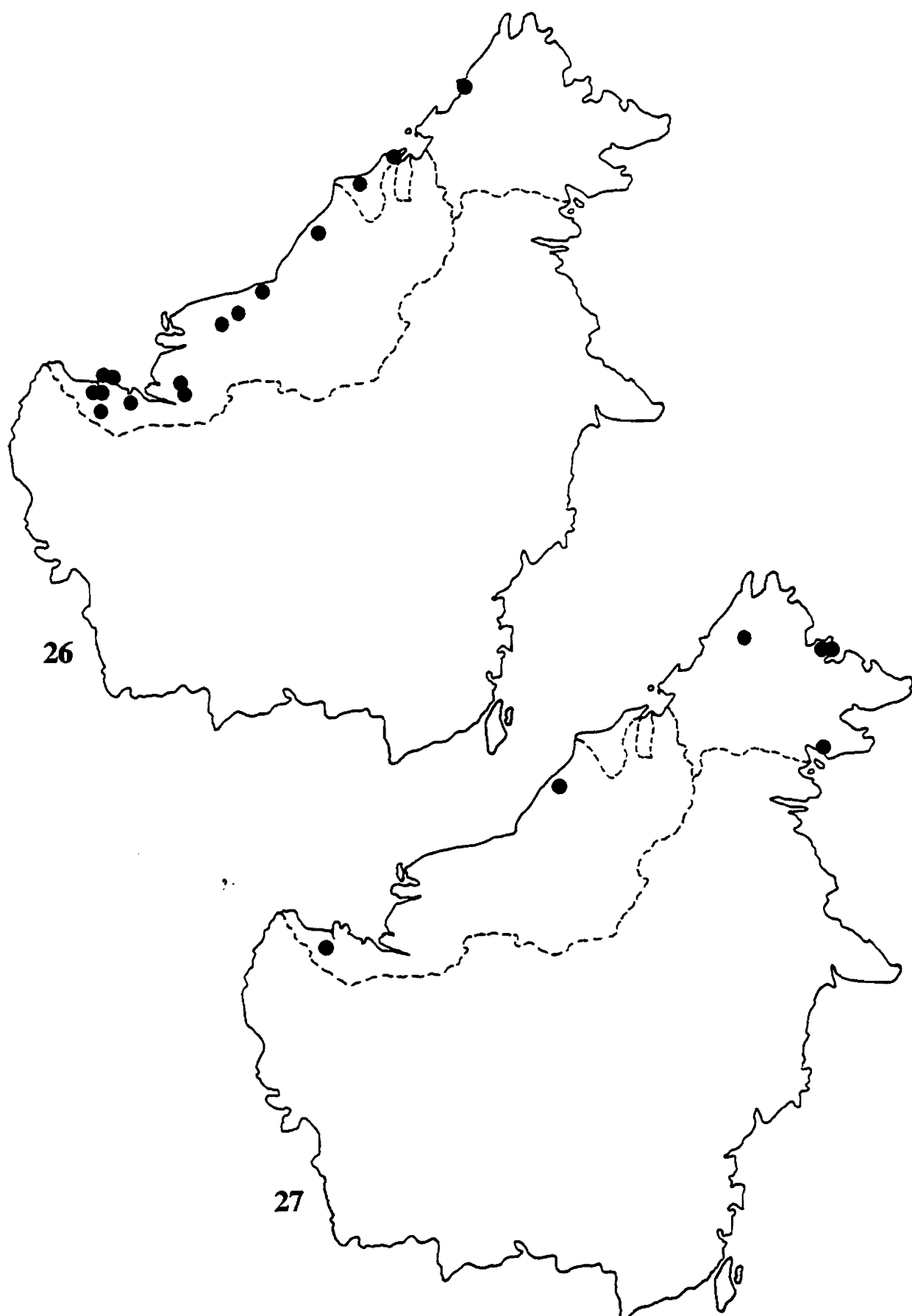


**Figures 16-19.** Apices of males' abdomens: 16, Lateral view of *L. brevipes*; 17, Lateral view of *L. catori*; 18-19, Dorsal and lateral views of *L. hosei*.





**Figures 20-25.** 20-21. Lectotype of *L. mindanaense*: 20, Fore leg; 21, Middle leg.  
22-25. *L. hosei*: 22-23, Middle leg; 24-25, Dorsal and lateral views of egg.



Figures 26-27. Distribution maps for: 26, *L. catori*; 27, *L. hosei*.

along; apical quarter ventro-anterior and ventro-posterior carinae each with an undulating lobe with a distinct triangular spine-like lobe and 2-3 minute spines, medio-ventral unarmed. Hind femur with ventro-anterior carina rather indistinct, apices of ventro-anterior and ventro-posterior each with one small and 1-2 minute spines. Dorsal carinae of fore tibia united to form a lobe running the length of the tibia, apex of lobe may be smooth or serrated; medio-ventral carina lobe-like, reducing in size apically. Dorsal carinae of middle tibia united; with two serrated lobes, one apically, one basally. All tarsi short, with segments 1-4 of similar size.

#### **Male (Figures 18-19)**

Head, body and legs mid brown or greenish-brown, hind femur red-brown particularly on the posterior surface. Occasionally the thorax has a few narrow dark green bands. Head and thorax densely granulose, femora and abdomen granulose, posterior of abdomen very sparsely granulose.

Antennae longer than the fore legs, basal segment slightly flattened, first two segments thicker than remainder. Head rectangular, one-and-a-half times longer than wide. Pronotum one-and-a-quarter times longer than wide, with a median transverse furrow. Mesonotum of almost uniform width but doubling in width near the posterior. Mesopleura projecting, increasing the width of the mesothorax to two-and-a-half times the middle of the mesonotum. Metanotum arched, narrowing slightly at the anterior; three times longer than the median segment. Abdominal segments 2-6 about four times longer than wide, 7th much shorter and widening, 8th and 9th dilated, wider than long (figure 18). Anal segment deeply cleft, forming two triangular lobes. Poculum deep, angular, with a slight keel, apex with a distinct flattened rim.

Ventro-posterior carina of fore femora with 2-3 small spines at the apex, ventro anterior unarmed; apices of ventro-posterior and ventro-anterior of mid femora with one small and 1-3 very small spines; ventro-posterior and ventro-anterior of hind femora each with two small spines. Dorsal carinae of middle femur indistinct except for a short section of dorso-posterior carina near the apex. Dorsal surface of fore tibia with a narrow lobe running the full length. Apex of middle tibia slightly thickened. All tarsi with basal tarsomere about as long as segments 2-3 combined.

#### **Egg (Figures 24-25)**

Capsule and operculum dark grey-brown, micropylar plate light grey or cream, capitulum orange. Capsule with polar mound, micropylar mound, ventral and dorsal surfaces concave near anterior end, ventral edge narrow, almost forming a keel. Polar mound with a central hollow, and lower on the dorsal side. Length 3.5mm (polar mound 0.4mm), height 3.0mm, width 2.2mm; operculum height 1.7mm, width 1.3mm.

#### **Comments**

*Hermogenes cristatus* is clearly a synonym of *hosei*, the mid femora of the holotypes have the same shape of lobes and spines, the differences described by Kirby are all variable characteristics. The differences found in *cristatus* are the presence of a lobe on the posterior of the pronotum and posterior of the mesonotum, a spine-like lobe on the posterior margin of the 2nd abdominal segment and wide lobe on the posterior margin of the 7th segment, and the lobes on the fore tibia are smooth until the apex where they widen quite suddenly; all these features can occur in cultured specimens of *hosei*. The holotype of *hosei* has a wide lobe on posterior of 5th abdominal segment, and two small lobes on anterior of 6th segment, and the lobes on the fore tibiae are broad and wavy. Some of the variations which occur in

this species have been illustrated by Singy (1988).

*Lonchodes rusticus* (Brunner) is clearly closely related to *L. hosei*, it may be distinguished by the basal lobe on the dorsal surface of the mid femur which is rounded in *rusticus* and serrated in *hosei*; the egg of *rusticus* does not have a partly concave ventral surface unlike *hosei*, and the capsule is smoothly ovoid whereas *hosei* has a keel-like compression of the dorsal and ventral edges. *L. rusticus* may be little more than small variety of *L. hosei*, or perhaps a subspecies but, until more is known about it, it seems wise to treat it as a distinct species.

I have not examined the type material of all the species which Günther placed as junior synonyms, however I have examined *L. mindanaense* (Brunner) which is clearly a different species (see below). It is unlikely that *Prisomera tuberculatum* Brunner and *Prisomera palawanica* Carl are correctly synonymised because both species were described from the Philippines, it is more likely that they are synonyms of *L. mindanaense*. As *Prisomera morbosum* Brunner was described from Sabah, it is quite likely that it is a synonym of *hosei*, or perhaps *L. rusticus* (Brunner).

It is clear from the illustration of *L. hosei papuanas* (Günther, 1930: fig 6) that this is the same species. Günther distinguished the subspecies on the basis of size, coloration and the presence of spines on the front of the lamina on the fore tibiae; all of these features occur in reared material from Sabah so *papuanas* cannot be regarded as a valid subspecies. It is likely that the locality of Günther's specimen is incorrect.

### Distribution and culture

Although this species occurs over a wide area of northern Borneo (figure 27), it is rare in Sarawak. Most of my collecting has been done in Sarawak and I have encountered only two specimens; I have spent only a few nights collecting in Sabah but have found this at two of the three sites which I have visited.

*Lonchodes hosei* was originally cultured from material collected in Sabah by Allan Harman in 1979 (Singy, 1988: 13) and was subsequently designated culture PSG 29. The original culture has been supplemented by material which I have collected in Sabah. Bramble and oak are the only foodplants which I have recorded for this species although it will probably feed on others.

### *Lonchodes mindanaense* (Brunner, 1907)

*Prisomera mindanaense* Brunner, 1907: 286. Lectotype [here selected] ♀ (SMTD) Mindando, Dapitan; Paralectotype ♂ (not located) Mindando.

[*Lonchodes hosei* (Kirby); synonymised in error by Günther, 1932b: 376.]

### Material examined

#### PHILIPPINES

Mindando, Dapitan.

♀ Lectotype (SMTD)

#### PHILIPPINES

Area not known (PSG 169)

♀ (PEB-2475), 2♂♂ (PEB-2474; PEB-2562), eggs (PEB-2518) captive reared, 1995.

### Comments

This species is currently in culture as PSG 169; I do not know from which part of the Philippines the culture originated. Although similar to *L. hosei* the female is clearly different as it lacks a distinct lobe at the base of the mid femur (figure 21). The apex of the male's abdomen is less dilated than in *L. hosei*. The egg of *mindanaense* is twice the size of *hosei* and has a smooth ventral surface. Apart from the lobe on the fore tibia which is of uniform width, my specimen agrees with the lectotype (figure 20) in all respects. The male

paralectotype is not with the female in the SMTD collection.

## References

- Bragg, P.E. (1991a) Spermatophores in Phasmida. *Entomologist*, 110(2): 76-80.
- Bragg, P.E. (1991b) Spermatophores chez les Phasmida. *Le Monde des Phasmes*, 14: 18-21. [translation of Bragg, 1991a]
- Bragg, P.E. (1992) Phasmida from Bako National Park. *Sarawak Museum Journal*, 43(64): 295-319.
- Brock, P.D. (1996) Catalogue to stick and leaf-insects (Insecta: Phasmida) associated with Peninsular Malaysia and Singapore. *Malayan Nature Journal*, 49: 83-102.
- Brunner von Wattenwyl, K. (1907) *Die Insektenfamilie der Phasmiden*. Vol. 2. Leipzig.
- Gray, G.R. (1835) *Synopsis of Phasmidae*. Longmans, London.
- Günther, K. (1930) Weitere Beiträge zur Kenntnis der Phasmoidenfauna Neu Guineas. *Mitteilungen aus dem Zoologischen Museum in Berlin*, 15: 729-747.
- Günther, K. (1932a) Die von Professor Dr. H. Winkler 1924/25 in Zentralborneo gesammelten Phasmoiden. *Zoologischer Anzeiger*, 101(3/4): 65-73.
- Günther, K. (1932b) Revision des Genus *Lonchodes* Gray. *EOS Madrid*, 8: 367-389.
- Günther, K. (1935) Ueber einige Phasmoiden aus der Sammlung des Herrn Dr. C. Willemse, Eijgelshoven. *Natuurhistorisch Maandblad Maastricht*, 24: 123-126 & 138-140.
- Günther, K. (1943) Die Phasmoiden (Orthoptera) der "Borneo-expedition Dr. Nieuwenhuis" aus dem Stromgebiet des oberen Mahakam. *Eos Madrid*, 19: 149-172.
- Haan, W. de (1842) Bijdragen tot de Kennis Orthoptera. in Temminck, *Verhandelingen over de natuurlijke Geschiedenis der Nederlandsche overzeesche Bezittingen*. volume 2.
- Hausleithner, B. (1984) Zur Systematik der Gattung *Lonchodes* Gray und die Erstbeschreibung des Weibchens von *L. haematopus* Westwood (Phasmatodea). *Entomologische Zeitschrift*, 94(11): 157-160.
- Hausleithner, B. (1989) Die Eier einiger *Lonchodes*-Arten (Phasmida). *Entomologische Zeitschrift*, 99(8): 102-112.
- Hausleithner, B. (1991) Eine Phasmidenausbeute aus dem Gebiet des Mount Kinabalu, Borneo (Phasmatodea). *Nachrichten des Entomologischen Vereins Apollo, Frankfurt*, N.F. 11(4): 217-236.
- Kirby, W.F. (1896) On some new or rare Phasmidae in the collection of the British Museum. *Transactions of the Linnaean Society of London*, (2)6: 447-475.
- Kirby, W.F. (1904) *A synonymic Catalogue of Orthoptera*. Vol. 1. London.
- Klante, H. (1960) Stabheuschrecken (Insecta, Phasmatodea) aus dem Naturkundemuseum Görlitz. *Abhandlungen und Berichte des Naturkundemuseums Görlitz*, 36(2): 89-101.
- Rehn, J.A.G. (1904) Studies in the Orthopterous family Phasmidae. *Proceedings of the Academy of Natural Sciences of Philadelphia*, 56: 38-107.
- Seow-Choen, F., Brock, P.D. & Seow-En, I. (1994a) The Stick Insects of Singapore. *Singapore Scientist*, 70: 10-14.
- Seow-Choen, F., Brock, P.D. & Seow-En, I. (1994b) An introduction to the stick and leaf-insects of Singapore. *Malayan Naturalist*, 48: 7-11.
- Shelford, R.D. (1916) *A Naturalist in Borneo*. 1985 edition, T. Fisher Unwin Ltd., London.
- Singy, X. (1988) PSG No. 29: *Lonchodes hosei*. *Newsletter of the Phasmid Study Group*, 35: 13-14.
- Westwood, J.O. (1848) *Cabinet of Oriental Entomology*. London.
- Westwood, J.O. (1859) *Catalogue of the Orthopterous Insects in the Collection of British Museum. Part I: Phasmidae*. London.

# Reviews and Abstracts.

## Book Reviews

**Phasmatodea** by Jacques Potvin. Published by J. Potvin. Softback, A4 portrait format (294mm high, 208mm wide), 251 pages. Price £30.00. - Reviewed by P.E. Bragg.

This book is a collection of black and white drawings of phasmids, with a contents list and an index to the species. The illustrations, all by J. Potvin, show life-size dorsal views of 130 species, and in most cases both the male and female are illustrated. There is one insect per page, with large species being accommodated by fold-out sheets. The lay-out of the book is very wasteful, with some small species occupying only 5% of an otherwise blank page; with very few exceptions both sexes could have been placed on the same page and consequently reduced the price of this book. Some small species are illustrated at both life size and twice life size. The contents are arranged taxonomically and a wide range is covered. There is a bias towards species which have been reared in captivity and quite a few species are illustrated for the first time. The names used for the species are not all correct, some are apparently based on misidentified museum specimens (e.g. *Echinoclonia laetior* on page 73). It is unfortunate that no PSG numbers are included, these would have been particularly helpful with some of the unidentified species.

**Wandelnde Blätter, Stab- und Gespenstschrecken** by Dieter Schulten. Published in 1995 by Entomologische Mitteilungen aus dem Löbbecke-Museum & Aquazoo, Düsseldorf. Softback, A5 portrait format (210mm high, 148mm wide) 132 pages, 8 colour plates, 75 black and white illustrations. Price 40DM. - Reviewed by P.E. Bragg.

This book, written in German, is a comprehensive introduction to rearing phasmids. It follows the usual format of such books: a general introduction to rearing followed by details of many of the commonly available species. The section on each species helpfully includes data on sizes of adults and eggs, hatching time and time taken to reach adult. As I do not read German I am unable to comment on the content of the general text but will comment on the illustrations and names used. Most of the 75 illustrations show several figures. They serve to give a good general impression of the type of stick insect but are not accurate enough to distinguish between similar species, the *Dares* for example could be either of two species which are currently widely cultured; the *Haaniella echinata* does not show two of the key diagnostic features of the species, despite the fact that they should be clearly visible in the views illustrated. The book includes some English common names, unfortunately in some cases they serve only to perpetuate earlier mistakes and confusion. *Acrophylla wuelfingi* is referred to as the Queensland Titan, a name which should only be applied to *A. titan*; the use of Queensland Titan stems from a misidentification when *wuelfingi* was first cultured more than twenty years ago. Two species are sold by UK dealers under the name "Sabah Spiny", *Aretaon asperrimus* and *Dares verrucosus*, the name most accurately describes the former but only the latter is mentioned in this book. "Mediterranean stick insect" could be applied to several species of *Bacillus* and I can see no value in using it for *B. rossius*. Many of the scientific names contain errors, these and some other errors are corrected below:

Page.

8. Top illustration: The elytron and mid leg are shown attached to the front of the mesonotum, they should be at the back of the segment.
29. *D. femorata* (Say, 1824) - not 1828.
32. *O. peruana*, - not *peruanas*.
39. *C. morosus* (Sinéty, 1901) - not Brunner, 1907.



45. (Brunner, 1907) - not Brunner, 1907.
  48. *L. modestus* (Brunner, 1907) - not Brunner 1907.
  52. (de Haan, 1842) - not 1849
  54. *P. laetus* (Kirby, 1904) - not *P. operculata* Redtenbacher, 1908.
  68. (Redtenbacher, 1908) - not Redtenbacher, 1908.
  82. *P. serratipes* (Gray, 1835) - not *acanthopus* (Burmeister, 1838).
  84. *A. wuelfingi* - not *wülfingi*.
  87. *E. versirubra* Serville, 1838 - not *E. herculeana*.
  89. (Macleay, 1826) - not MacLeay, 1826.
  92. *rossius* (Rossi, 1790) - not *rossii* (Fabricius, 1793).
  94. *D. verrucosus* Redtenbacher, 1906 - not *D. breitensteini* Westwood, 1859 [This is assuming that it is PSG 69, it is not possible to tell from the illustration. In any case, *D. breitensteini* was described by Redtenbacher, 1906 not by Westwood]
  98. *muelleri* - not *mülleri*.
  113. Serville, 1838 - not 1839.
  114. Stoll, 1813 - not 1787.
- plate IV      This has been printed sideways.

## Phasmid Abstracts

The following abstracts briefly summarise articles which have recently appeared in other publications. Some of these may be available from local libraries. Others will be available in university or college libraries, many of these libraries allow non-members to use their facilities for reference purposes free of charge.

The editor of *Phasmid Studies* would welcome recent abstracts from authors so that they may be included in forthcoming issues. In the case of publications specialising in phasmids, *Phasma* and *Le Monde des Phasmes*, only the longer papers are summarised.

### Publication dates

Volumes 31 and 32 of *Le Monde des Phasmes* were both published in 1996, not 1995 as stated on the covers. Volume 31 ("Septembre 95") was published on 1st March 1996 and volume 32 ("Decembre 95") on 13th May 1996.

**Abercrombie, I.** (1995) Beobachtungen bei der Eiablage bei *Epidares nolimetangere* (de Haan) und *Dares ulula* (Westwood). *Arthropoda*, 3(3): 34-36.

A German translation of the article discussing the egg laying behaviour of *Epidares nolimetangere* (de Haan) and *Dares ulula* (Westwood) which originally appeared in *Phasmid Studies*, 1(1): 2-4.

**Abercrombie, I.** (1996) Waarnemingen bij het eierleggen van *Epidares nolimetangere* (de Haan) en *Dares ulula* (Westwood). *Phasma*, 6(21): 1-5.

A Dutch translation of the article on egg laying which originally appeared in *Phasmid Studies*, 1(1): 2-4. This version also includes illustrations of *Dares ulula* (Westwood) by P.E. Bragg.

**Berenbaum, M.R.** (1995) *Bugs in the system: Insects and their impact on human affairs*. Addison-Wesley Publishing Ltd. 377 pages. ISBN: 0-201-62499-0.

This book covers all aspects of the harmful and beneficial interactions between humans and insects, with emphasis on the beneficial interactions. The classification, physiology, behaviour, social lives, food, biological control, and diseases caused by insects are some of the topics covered. The history of entomology in the US and various legal considerations are

also discussed. Sections on human entomophaga, the history of pest control, and insects as medicine are also included. The work is primarily intended for the general, public, and will be of use to anyone interested in insects and their influence on human life. Photographs, line-drawings, and diagrams illustrate the text, and an appendix with an introduction to the insect orders are provided. The work is indexed.

**Bragg, P.E.** (1995) A new species of *Phenacephorus* from Kalimantan (Insecta: Phasmida: Heteronemiidae: Lonchodinae). *Zoologische Mededelingen*, **69**: 203-208.

*Phenacephorus parahaematomus* spec. nov. is described and illustrated. The species is based on two male specimens which were collected in Borneo in 1925. The stout spines on the metanotum and general form closely resembles *Lonchodes haematomus* Westwood but *P. parahaematomus* has a spinose mound on the back of the head and spines on the pronotum and abdominal segments. Some new distribution data is given for *Phenacephorus auriculatus* (Brunner), and the egg is described and illustrated.

**Bragg, P.E.** (1995) A new species of *Nearchus* (Insecta: Phasmida: Phasmatidae) from Borneo, and a description of the male of *N. redtenbacheri*. *Zoologische Mededelingen*, **69**: 273-279.

*Nearchus foliatus* spec. nov. is described from a single female specimen collected in eastern Kalimantan in 1925. This species is readily distinguished from others in the genus by the large foliaceous lobes on the legs. A key to the genus is provided; *Nearchus maximus* Redtenbacher is designated as the type species. The male and egg of *N. redtenbacheri* Dohrn are described for the first time; males of this genus have not been recorded previously.

**Brock, P.D.** (1995) An introduction to the world of stick and leaf insects. *Insect World International*, **1**: 25-27.

A general introduction to phasmids, including culture notes and colour photographs of a female *Phyllium bioculatum*, a mating pair of *Timema cristinae*, and a gynandromorph of *Heteropteryx dilatata*.

**Brock, P.D.** (1995) Notes on the smooth stick insect *Clitarchus hookeri* (White) in Tresco Abbey gardens. *BRICS Journal*, **1**: 11-14.

Detailed information on *Clitarchus hookeri*, dealing with records from the gardens, and notes on foodplants in the gardens and in captivity. *C. hookeri* is confirmed to browse on many plants and in captivity readily accepted *Leptospermum scoparium*, *Leptospermum* sp., *Metrosideros robusta*, *Metrosideros* sp., *Eucalyptus gunnii*, *Rubus* sp., and more reluctantly fed on *Cupressus macrocarpa*. Two females collected in 1992 laid an average of 327 eggs each between October 1992 and January 1993, an average of 24 each per week. The author expresses concerns about indiscriminate collecting from the gardens.

**Brock, P.D.** (1995) A remarkable new genus of stick-insect (Insecta: Phasmatodea, Pseudophasmatidae) from peninsular Malaysia. *Malayan Nature Journal*, **49**(1): 31-35.

A spectacular small, spiny stick insect from the Cameron Highlands, peninsular Malaysia is described as a new genus *Pinnispinus*, belonging to the family Pseudophasmatidae, subfamily Ashiphasmatinae. This paper deals with taxonomic descriptions of the adults and egg, along with general notes on the habitat and behaviour of these insects.

**Brock, P.D.** (1996) A catalogue of stick and leaf-insects (Insecta: Phasmida) associated with peninsular Malaysia and Singapore. *Malayan Nature Journal*, **49**(2): 83-102. [The journal is dated "November 1995" but the actual publication date was 26.2.1996]

This is the first published catalogue of stick and leaf-insects recorded or described from peninsular Malaysia and/or Singapore (93 species). Genera are listed in alphabetical order within subfamilies. Type locations, sex of types or details of syntype series are provided, including documented present location of types where these can be determined. Thirty-nine new synonyms are recorded and 34 new lectotypes designated in this work, 14 new type species are designated for genera, where appropriate, and four species are transferred to different genera. The references section includes references containing descriptions of species recorded or described from peninsular Malaysia and/or Singapore; full details of localities and descriptions and illustrations will be included in a forthcoming book on this fauna. [Editor's note: The designation of the type species for *Nearchus* Redtenbacher is invalid, the designation by Bragg has priority (*Zool. Med. Leiden*, 69: 273)]

**Brock, P.D. & Seow-Choen, F.** (1995) Notes on the stick-insect genus *Abrosoma* in peninsular Malaysia (Insecta: Phasmida) with description of a new species. *Malayan Nature Journal*, 49(1): 19-27.

A new species of *Abrosoma* from Tanah Rata, Cameron Highlands, peninsular Malaysia is described. *Proscelus modestus* (Redtenbacher) is re-named *Abrosoma festinatum* and redescribed. The egg is also figured for the first time. The genus *Proscelus*, erroneously placed in the family Heteronemiidae, subfamily Necrosiinae is now listed as a new synonym of *Abrosoma*, family Pseudophasmatidae, subfamily Aschiphasmatinae.

**Cruse, H. & Bartling, C.** (1995) Movement of joint angles in the legs of a walking insect, *Carausius morosus*. *Journal of Insect Physiology*, 41(9): 761-771.

This paper provides a quantitative description of the leg movement of a stick insect walking in three different situations, namely walking tethered on a treadwheel, on a slippery glass plate and walking free on a horizontal plane. These descriptions concern the trajectories of the end of the tibia and the changes of the femur-tibia joint ( $\gamma$ ), the coxa-trochanter joint ( $\beta$ ) and the movement of the thoracic-coxal joint of all three pairs of legs. As the latter joint comprises a ball and socket joint, the changes of the position of the rotational axis of this joint have been measured. No simple rule could be found which allowed the control of more than one joint of a leg by a common control parameter. Co-ordination of the joints of one leg seems to be simpler during the swing than during the stance movement. Measurements of the forces at the end of the swing movement indicate that there is no information transfer between legs with respect to an expected height of the ground at the end of the swing movement, nor is there an internal "expectation" which may have led to a decrease of force before probable ground contact.

**Deschandol, A.** (1996) Le minétisme chez les *Phyllium*. *Le Monde des Phasmes*, 31: 20-22.  
Notes and illustrations of mimicry in *Phyllium* spp.

**D'Hulster, K.** (1996) Het tekenen van wandelende takken. *Phasma*, 6(21): 6-11.

A summary of the talk on illustrating phasmids which was given by P.E. Bragg at the PSG meeting in January 1996.

**Gorkom, J. van** (1996) PSG no. 138: *Lonchodes modestus* (Brunner, 1907). *Phasma*, 6(21): 12-15.

Short notes on *Lonchodes modestus* (Brunner), with colour photographs of the male and the female.

**Größer, D.** (1996) L'appareil stridulatoire chez certaines espèces de *Phyllium* (Phasmatodea: Phylliidae). *Le Monde des Phasmes*, 32: 12-13.

The stridulatory organs of *Phyllium bioculatum* Gray and *P. giganteum* Hausleithner, illustrations and notes.

**Hausleithner, B.** (1992) Eine neue *Menexenus*-Art aus NE-Indien und Vorarbeiten zu einer Revision der Gattungen *Menexenus* und *Neohirasea* (Phasmatodea: Phasmatidae: Lonchodinae). *Entomologische Zeitschrift*, 102(22): 423-434.

A new *menexenus* species, *M. nudiusculus* n.sp., from NE India is described and figured. It is nearest related to *Menexenus semiarmatus* (Westwood), but differs in the form of the last abdominal segment (in the male), and in the form of head spines and the lobe-like expansion of the seventh abdominal segment (in the female). Some notes on the *Menexenus* and *Neohirasea* in the collection of the Naturhistorisches Museum, Wien, are given. *Neohirasea lugens* (Brunner v. W., 1907) is a junior synonym of *N. japonica* (de Haan, 1842) (n.syn.), and *N. modificata* (Brunner v. W., 1907) is a junior synonym of *N. maerens* (Brunner v. W., 1907) (n.syn.). Lectotypes for six species have been designated.

**Hennemann, F.** (1995) Unterschiede zwischen zwei Vertretern der Gattung *Eurycnema* Serville 1839: *Eurycnema versifasciata* (Serville) und *Eurycnema goliath* (Gray). *Arthropoda*, 3(3): 39-45.

The differences between two species of the genus *Eurycnema* Serville 1839 (*E. versifasciata* Serville and *E. goliath* (Gray)) are described and problems of the synonymy of *E. versifasciata* are discussed. [Editor's note: Serville 1839 should read Serville 1838, and the illustrations on pages 43 and 44 have been computer-printed with the longitudinal axes compressed]

**Hennemann, F.** (1995) Einige Bemerkungen zur Identität von *Calvisia coerulescens* Redtenbacher 1908 (Phasmatodea). *Entomologische Zeitschrift*, 105(24): 497.

In *Entomologische Zeitschrift* 105(16): 321-325, the male of *Calvisia coerulescens* Redtenbacher was described. However, there was a misidentification and the correct name of the described specimen turned out to be *Calvisia virbius* (Westwood). *Calvisia westermanni* (Westwood) is a synonym of *C. virbius*. *Calvisia coerulescens* Redtenbacher remains a separate species.

**Hennemann, F.H., Conle, O.V. & Brückner, M.** (1996) *Phaenopharos herwardeni* n.sp. - eine neue Phasmide aus Thailand und die Beschreibung der Eier von *Phaenopharos struthioneus* (Westwood 1859) (Phasmatodea: Phasmidae: Necrosiinae). *Entomologische Zeitschrift*, 106(4): 153-159.

A new species of Phasmidae, *Phaenopharos herwardeni* n.sp. from Thailand, is described and illustrated. The eggs of the hitherto single species in the genus, *P. struthioneus* (Westwood, 1859) are described and illustrated for the first time and a lectotype for this genus is designated. [Editor's note: This lectotype designation is invalid, the designation by Brock has priority (1996, *Malayan Nature Journal*, 49: 92)]

**Hennemann, F.H., Gehler, A.S. & Conle, O.V.** (1995) Katalog des im Museum für Naturkunde in Stuttgart vorhandenen Typusmaterials der Insektenordnung Phasmatodea. *Entomologische Zeitschrift*, 105(21): 435-439.

A catalogue is provided of the type material of Phasmatodea (24 species) deposited in the Museum für Naturkunde in Stuttgart (SMNS). All data for the material concerned are



given along with taxonomic and relevant comments.

**Langlois F.** (1996) Un exemple de cage de chasse. *Le Monde des Phasmes*, 23-26.

Instructions for making a cage for use on phasmid collecting trips, made from a tubular frame covered with netting.

**Lee, M.** (1996) Etude sur la distribution des phasmes en Grande-Bretagne. *Le Monde des Phasmes*, 32: 5-11.

A translation of the first half of the author's paper "A survey into the distribution of the stick insects of Britain" from *Phasmid Studies*, 4(1): 15-23.

**Lelong, P.** (1996) Les Phasmes de France et d'ailleurs. *Le Monde des Phasmes*, 31: 3-10.

Illustrations, distribution maps and notes on the three species of phasmids which occur in France.

**Lelong, P.** (1996) *Baculum extradentatum* (Brunner, 1907) P.S.G. No. 5. *Le Monde des Phasmes*, 31: 11-13.

Illustrations and notes on rearing *Baculum extradentatum* (Brunner).

**Lelong, P.** (1996) *Carausius morosus* (Sinéty, 1901) P.S.G. No. 1. *Le Monde des Phasmes*, 31: 14-16.

Illustrations and notes on rearing *Carausius morosus* (Sinéty, 1901).

**Lelong, P.** (1996) Le dictionnaire des Phasmes. *Le Monde des Phasmes*, 32: 15-20.

Illustrations and French terminology used to describe the parts of the head of phasmids.

**McNamara, D.** (1996) A note on *Bacillus rossius*, the Corsican stick insect. *Bulletin of the Amateur Entomologists' Society*, 55(404): 31-32.

Reports *Bacillus rossius* apparently breeding in the wild in Uxbridge, Middlesex, U.K. The specimens are assumed to be the progeny of a culture which was disposed of in a garden in 1986; nymphs were found in the garden in 1993, and an adult in July 1994.

**Scali, V., Tinti, F., Mantovani, B. & Marescalchi, O.** (1995) Mate recognition and gamete cytology features allow hybrid species production and evolution in *Bacillus* stick insects. *Bolletino di Zoologia*, 62(1): 59-70.

The increasing number of recognized hybrid unisexual complexes among invertebrate and vertebrate animals has promoted investigations about their composition and origin. Morphological, karyological and genetic (protein and DNA) analyses clearly show that, owing to their persistence and incomplete reproductive isolation from ancestors, several all-female complexes are much more diversified than generally assumed and that they may also have an evolutionary role. Here the case of the stick-insects of the genus *Bacillus* is reported in some detail. This holomediterranean genus comprises three well differentiated species that in Sicily have hybridized repeatedly. The *Bacillus* mate-recognition system has not followed the species-specific differentiation of the allozyme-coding loci, allowing interspecific crosses to occur in areas of species sympatry with the production of two hybridogens, a corresponding allodiploid parthenogen and a trihybrid triploid parthenogenetic species. Hybridogenetic females eliminate the paternal haploset (*grandii*) while passing the unassorted *rossius* hemiclone to offspring, which will be again of F<sub>1</sub> hybrid structure through a real fertilization by host male sperm. The polyspermic eggs of the hybridogens can also produce full-paternal

fertile progeny of both sexes (androgenetics), when mixis occurs between two sperm heads. The parthenogenetic mechanism of the corresponding hybrid *B. whitei* is very similar to the hybridogenetic one, excepting the automatic re-use of the segregated *grandii* haploset; therefore *B. whitei* offspring clonally maintain the maternal hybrid structure. The trihybrid *B. lynceorum* produces clonal descendants through an apomictic mechanism undergoing two seemingly normal meiotic divisions. Each *Bacillus* hybrid actually realizes a different egg maturation process; however, the three share one important feature: an intrameiotic DNA extra-doubling, leading to the formation of four-stranded chromosomes, and enabling the meiotic system to produce balanced gametes even under different ploidy level and hybrid structure. The extra-round of DNA synthesis seems to be triggered by the hybrid condition impairing the synaptic process. Also the parthenogenetic *B. whitei* produces androgenetics and it is even capable of incorporating a third genome into its automictic but clonal eggs, following fertilization by *B. grandii* or *B. rossius* males with the production of fertile "synthetic" triploids. These findings are evidence of clonal unisexuals reproductively interacting with related bisexuals and also suggest that evolutionary pathways have been undertaken by *Bacillus*. Also other unisexual complexes seem to have undergone similar microevolutionary steps and their reproductive traits and persistence, longer than commonly assumed, make increasingly difficult to think of the whole of unisexuals as "dead ends" or "blind alleys".

Scofield, A.M., Witham, P., Nash, R.J., Kite, G.C. & Fellows, L.E. (1995) Castanospermine and other polyhydroxy alkaloids as inhibitors of insect glycosidases. *Comparative Biochemistry and Physiology*, A 112(1): 187-196.

The inhibition of glycosidase activity by a range of polyhydroxy alkaloids was studied in a number of insect species from the orders Orthoptera, Phasmida, Dictyoptera, Diptera and Coleoptera. Glycosidase activity was inhibited by a number of the alkaloids and the pattern of inhibition of hydrolysis of beta-glucosides and most alpha-glucosides (except trehalose) was different from that in mammals. 2R,5R-dihydroxymethyl-3R,4R-dihydropyrrolidine inhibited both alpha-glucosidase, including trehalase, and beta-glucosidase activity strongly in insects while castanospermine was a significant inhibitor only of beta-glucosidase activity, trehalase and in the Tenebrionidae, isomaltase and additionally, maltase in *Zophobas morio*. The identification of an isomaltase in the Tenebrionidae illustrates the value of the alkaloids as taxonomic tools.

Seow-Choen, F. (1995) The stick-insect *Datames oileus* (Westwood) 1859 (Phasmida). *Bulletin of the Amateur Entomologists' Society*, 54(403): 239.

Reports some foodplants of *Datames oileus* (Westwood) from Singapore: *Curculigo latifolia*, *Dieffenbachia* sp., *Uncaria gambir*, *Aidia wallichiana*, *Urophyllum glabrum*, *Daemonorops* sp. (close to *D. didymophylla*, and *Scindapsus aureus*. In the UK they will feed on aroids and Wandering Jew.

Seow-Choen, F. & Brock, P.D. (1996) A rare stick-insect from Singapore: *Lopaphus brachypterus* (de Haan) 1842 with descriptions of the male and egg. *Bulletin of the Amateur Entomologists' Society*, 55(405): 79-82 & plate 96H.

The male of *Lopaphus brachypterus* (de Haan, 1842) is briefly described and the male, female, and egg are illustrated; the colour plate shows a male and a female. A table gives measurements for the males and females. [Contrary to indications in the title, the egg is not described].



**Tinti, F. & Scali, V.** (1995) Allozymic and Cytological Evidence for Hemiclonal, All-Paternal, and Mosaic Offspring of the Hybridogenetic Stick Insect *Bacillus rossius-grandii grandii*. *Journal of Experimental Zoology*, **273**(2): 149-159.

*Bacillus* hybridogens represent the first example of hemiclonal reproduction among invertebrates and they were analyzed in the present study for comparison with vertebrate hybridogenetic complexes (*Poeciliopsis* and *Rana*). Experimental crosses of southeastern hybridogenetic *B. rossius-grandii grandii* females with both the parental species and hybrid males were carried out to test the reproductive potential of hybridogens. Allozyme and chromosome markers indicated that hemiclonal females actually reproduced in a variety of ways. Hybridogenesis was the most common and the *rossius* unassorted haploset was passed to the progeny while the *grandii* haploset was discarded during meiosis and replaced by that of the fathering male. Androgenesis, which was much rarer, led to the production of two types of all-paternal offspring: uniparental progeny of both sexes and all-male progeny with the same allozyme and chromosome structure as their father. Mosaics of two kinds were also produced: the "h + h" type, with two different hybridogenetic cell lines; and the "h + a" type, with one hybridogenetic and one androgenetic cell line. Mosaics evolved into intersexes when their cell lines were sexually discordant. Among the evolutionary outcomes of this wide array of reproductive ways seems to be a shift from hemiclonality to clonality. This possibility is supported by the well-established parthenogen *B. whitei* and the occasional production of rare invariant specimens from the northwestern hybridogenetic form *B. rossius-grandii benazzii*. *Bacillus* and other unisexuals provide evidence of numerous reproductive interactions between hybrids and their bisexual relatives: the occurrence of such interactions may play an important role in the persistence, diversification and evolution of unisexuals.

**Vandeurzen, A.** (1996) PSG no. 118: *Aretaon asperrimus* (Redtenbacher) -Een wandelende tak in het terrarium. *Phasma*, **6**(21): 15-19.

A report on rearing *Aretaon asperrimus* (Redtenbacher), with illustrations by P. Jennings and E. Newman.

**Ziegler, U.** (1995) Ein gynandromorphes Exemplar von *Phyllium bioculatum* (Gray) (Insecta: Phasmida). *Arthropoda*, **3**(3): 32-33.

A gynandromorph specimen of the leaf insect *Phyllium bioculatum* Gray is described and figured. The left side of the insect looks like a normal female. The right side of the insect shows typical male parts: two wings, smaller and brown coloured legs, two ocelli. [This paper was originally published in *Entomologische Zeitschrift*, **99**(3): 30-32.]

**Zompro, O.** (1995) Beschreibung des Männchens von *Planispectrum bengalensis* (Redtenbacher, 1906) (Phasmida: Bacillidae). *Entomologische Zeitschrift*, **105**(13): 257-259.

The male of *Planispectrum bengalensis* (Redtenbacher, 1906) is described and illustrated for the first time.

**Zompro, O.** (1995) *Baculofractum* n. gen. - ein neues Genus der Phasmida. *Entomologische Zeitschrift*, **105**(24): 488-491.

A new genus, *Baculofractum*, is introduced for *Carausius insignis* Brunner, 1907 and the male and egg of this species are described for the first time.

**Zompro, O.** (1996) Beiträge zur Kenntnis philippinischer Phasmiden, I. *Entomologische Zeitschrift*, **106**(4): 160-164.

Records of some Philippine phasmids are published in this paper. The female of

*Eubulides igorrote* Rehn & Rehn, as well as the eggs of this species and of *Orthomeria pandora* (Westwood) are described and figured for the first time.

### Publications noted

The following publications have been noted but no abstract has been received.

**Bueschges, A. & Wolf, H.** (1995) Nonspiking local interneurons in insect leg motor control: I. Common layout and species-specific response properties of femur-tibia joint control pathways in stick insect and locust. *Journal of Neurophysiology, (Bethesda)*, **73**(5): 1843-1860.

**Key, K.H.L.** (1994) *Phasmatodea (Stick-insects)*. Pages 297-301 in Naumann, I.D. (Editor), *Systematic and applied entomology: an introduction*. Melbourne University Press. Total 484 pages. ISBN: 0-522-84518-5.

## Advertising in Phasmid Studies

*Phasmid Studies* has a worldwide circulation of about 500 copies. Full-page, half-page or quarter-page adverts can be accepted. For details of the costs and restrictions contact: P.E. Bragg, 51 Longfield Lane, Ilkeston, Derbyshire, DE7 4DX, U.K.

# The influence of a cold period in the development of the embryo of *Clonopsis gallica* (Charpentier).

W. Potvin, Brusselbaan 7, 1600 Sint-Pieters-Leeuw, Belgium.

## Abstract

An experiment with *Clonopsis gallica* (Charpentier) shows the differences in egg development and hatch rate between eggs having undergone a cold period and eggs being kept at a constant room temperature. The onset of hatching is delayed by a cold period during incubation but the total number hatching is unaffected.

## Key words

Phasmida, Phasmatodea, diapause, egg development, *Clonopsis gallica*.

## Material

Three adult females of *Clonopsis gallica* (Charpentier) were obtained on the 23<sup>rd</sup> of April 1995 from captive reared stock from Gert Baarda, at a meeting of the Dutch/Belgian group Phasma. When I arrived home, I started feeding them bramble and rose, they were never sprayed and there was no soil covering on the floor of the cage. Consequently, the eggs were always dry, being at an atmospheric relative humidity of 50-60%. The temperature was constantly between 19°C and 23°C, only varying slightly between day and night.

All the females died the same week, on the 7<sup>th</sup> of August 1995 the last female died. Then I collected all the eggs, kept exactly 200 of them and gave the rest away to interested breeders.

## Method

The 200 eggs were split (at random): 100 which would undergo a cold period (constantly at 10-12°C) for three months of their development, and 100 were kept at constant room temperature (at 19-23°C) during the whole development.

Half of the 200 eggs were put into a black photographic film tube, which was put into the cellar at 10-12°C, day and night. The other 100 eggs were used as a control group and put into an identical box in my bedroom, at a temperature between 19°C and 23°C.

On the 2<sup>nd</sup> of November 1995 the eggs having undergone a cold period were taken into my bedroom and put onto a slightly humid layer of soil in a transparent box of 15 x 7 x 7 cm. At the same time, the 100 eggs in the control group were also incubated at exactly the same way. The two incubation boxes were put next to each other in ambient conditions (no direct sunlight, no extra heating, etc.). Further, the two boxes were treated at the same way: wetting the soil in both boxes at the same time and with about the same quantity of water.

The first nymphs hatched on the 4<sup>th</sup> of December 1995. From then on each hatched nymph was noted around 0800 each day. On the 25<sup>th</sup> of February 1996 the last nymph hatched. The eggs were kept in the boxes for several months more, but no more nymphs were seen.

## Results

The results are recorded in table 1, and are shown on Graph 1 so that the rate of hatching is clearly seen.

## Discussion

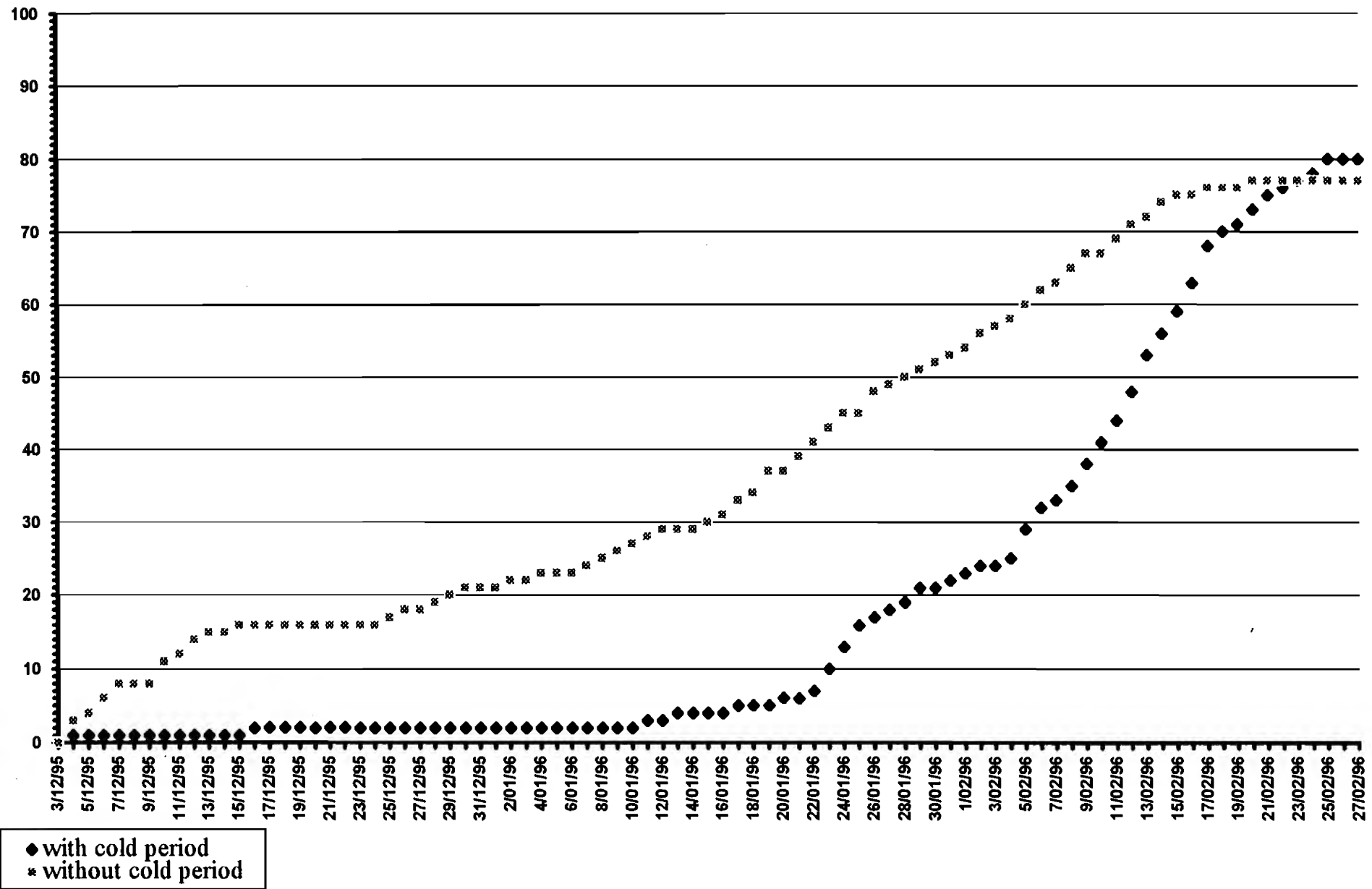
We see from the graph that the rate of hatching of the eggs in the control group is more linear than the cooled group. The nymphs start hatching at a certain day and continue at a more or less constant hatching rate, which agrees with the constant egg laying rate of the adult females. This means that each embryo takes about the same time to develop. At a certain day the hatching suddenly stops, just as the egg laying had suddenly stopped because

of the death of the adults.

	With cold period			Without cold period		
	Dec.	Jan.	Feb.	Dec.	Jan.	Feb.
Day	1995	1996	1996	1995	1996	1996
1	0	0	1	0	0	2
1	0	0	1	0	1	2
3	0	0	0	0	0	2
4	1	0	1	1	1	1
5	0	0	4	1	0	2
6	0	0	3	2	0	2
7	0	0	1	2	1	2
8	0	0	2	4	1	2
8	0	0	4	0	1	2
10	0	0	3	3	1	1
10	1	1	3	1	1	2
12	0	0	4	2	1	2
13	0	1	5	1	1	1
14	0	0	3	0	0	1
15	0	0	3	1	1	1
16	1	0	4	0	1	0
17	0	1	0	0	2	1
18	0	0	1	0	1	0
20	0	0	1	0	3	0
20	0	1	2	0	1	1
21	0	0	2	0	2	1
22	0	1	1	0	2	0
23	0	3	1	0	2	2
24	0	3	1	5	2	0
25	0	3	2	1	0	0
26	0	1	0	1	3	0
27	0	1	0	0	1	0
28	0	1	0	1	1	0
29	0	2	0	1	1	0
30	0	0	-	1	1	-
31	0	1	-	0	1	-

**Table 1:** Number of nymphs hatching from each group of eggs.

Graph 1: The total hatching rate as function of time.



Contrary to this, the curve for the cold group is more sigmoidal. Hatching starts very slowly and the hatching rate per day grows to a maximum, which makes the curve steeper. Once this maximum is reached, the hatching rate decreases and finally becomes zero, so that the curve flattens again. The curve has a flattened S-shape, typical of a sigmoid curve.

It is remarkable that in both boxes the nymphs started hatching exactly at the same day. This should be seen as a coincidence as the cooled group still stays at one hatched nymph when the control group has already passed the ten first hatchings, so the first nymph of the cooled group may be disregarded.

Near the end the curve for the cooled group passes the control group and remains above it. However, the final difference is not large. The total hatching percentage of the eggs being kept at a constant temperature is 77%. The total hatching percentage of the eggs having undergone a colder period is only slightly higher (80%), so we can conclude that the influence of a cold period on the total hatching percentage is almost nil.

### **Conclusion**

Discounting the first nymph of the cooled group, we can see that this group starts hatching about six weeks later than the control group. As the cold period was at a different stage for different eggs, some eggs might already have completed their diapause before going into the cold. Therefore we should not see the cold period as obligatory diapause, but rather as a slow-down of the general development, which explains why the cold group starts hatching later.



# A new culture of the subfamily Pachymorphinae from Thailand

Mark Bushell, 2 Fanconi Road, Dargets Wood, Chatham, Kent, ME5 8DE, UK.

## Abstract

This paper describes the male and female adults of PSG 179 an unidentified species from the subfamily Pachymorphinae from Thailand. Adults and egg are illustrated, with a general report of nymphs, defensive features and foodplants.

## Key words

Phasmida, Pachymorphinae, Thailand, Foodplants, Egg.

## Culture Origin

This species was collected by Barry Clarke in November 1995 from Thailand. It was found in the area between Pattaya Town and the Cambodian border at sea level, resting in grassland. The species was caught with another similar but distinct species. One pair of each species was brought back, both laying a few eggs before dying. All of the eggs laid by this species hatched and have produced enough insects to be shared between the collector and myself. The pair that has been given to me is described below.

## Female (figure 1)

The female has a body length of 80mm, with the total length including the legs being 150mm. The antennae are short (5mm) and are very similar to *Bacillus rossius* and are a dark pink in colour. The head is considerably longer than wide, and the eyes are small and black.

The body is green: with the dorsal surface dark green, and the ventral surface much lighter. The legs are long and slender. The trochanter is a pinky-red colour. The first tarsal segment on all of the legs is considerably longer than the other tarsomeres. The cerci are also quite long, and play an important role in egg laying; they are used to position the egg.

## Male (figure 2)

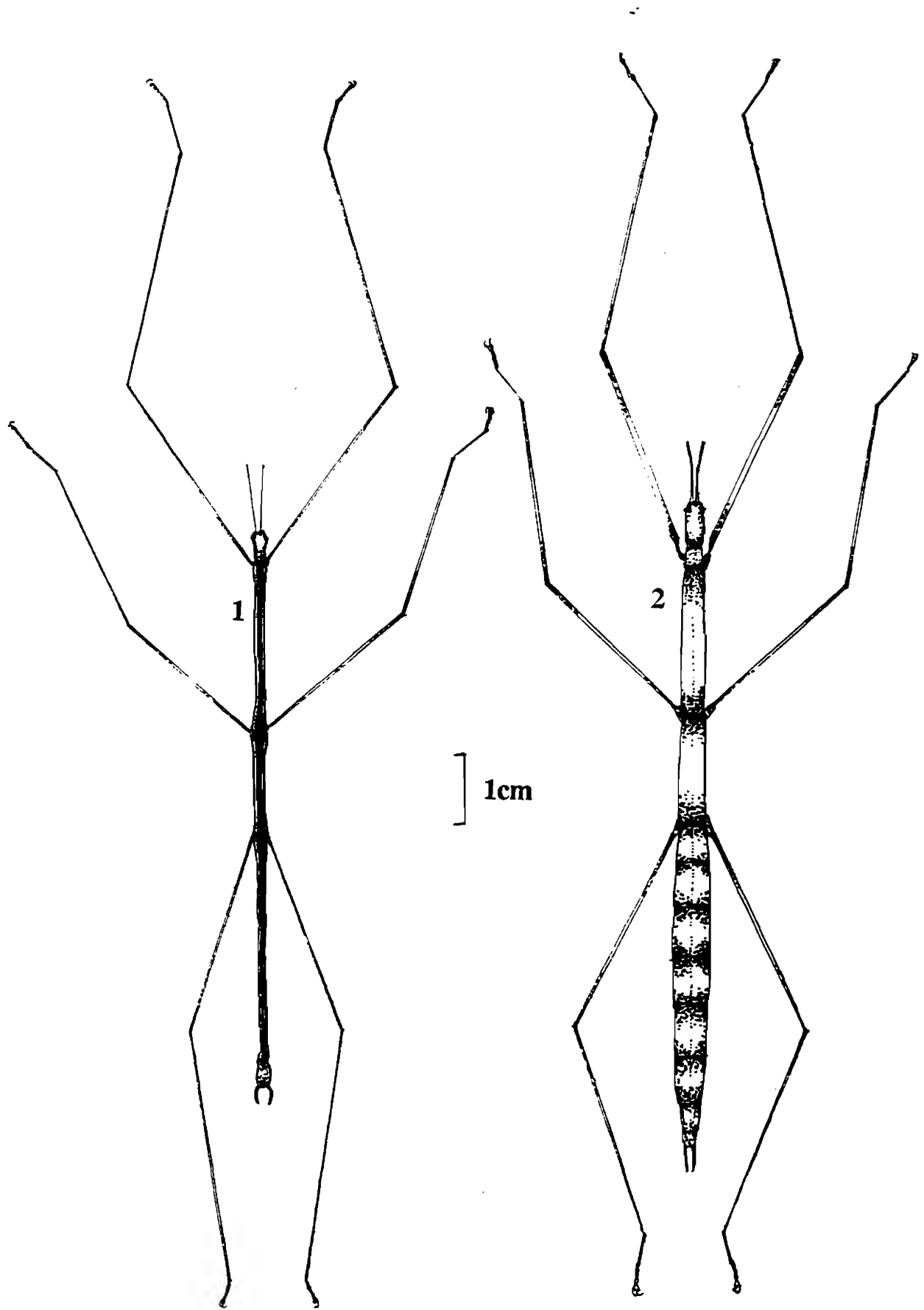
The male has a body length of 75mm, with a total length (including the legs) of 150mm. The antennae are longer than the female's, but are still quite short, being only 10mm. The body and head are a light brown colour, with black longitudinal stripes on the dorsal surface. The light brown turns a dark rosewood-red at night. The legs are again long and slender, and are an attractive shade of olive-green.

The head is similar to the female's, but much slimmer. Once again, the first tarsal segment is considerably longer than the other tarsomeres. The cerci are long and pincer-like, and are used to clasp the female during mating.

## Eggs (figure 3)

The eggs are brown with a rough surface. They are 8mm long, with the maximum width being 1mm. They taper towards the polar end and the operculum has a number of small spines around the rim in a sort of "crown". The micropylar plate stretches along the whole length of the egg and is glued to the surface with an adhesive produced during oviposition. Hatching occurs after a short time and was recorded as soon as 4-6 weeks by the collector. Eggs need to be kept warm and humid if they are to do well; Barry had a 100% hatch rate!

Two methods of laying have been observed; most eggs being laid directly onto the stems of the foodplant. The female lays the eggs by secreting an adhesive liquid from the tip of the abdomen onto the surface to which the egg is applied. One method is with the micropylar plate down, the whole of the egg being flush to the stem. The other is with the polar end only attached to the stem, with the egg pointing upwards at an angle of approximately twenty degrees.



**Figures 1 & 2.** PSG 179: adult male and female.

### Nymphs

Newly hatched nymphs are very similar to *Baculum thaili*, but are a light green. As they develop, the males may be distinguished because they are slimmer. The nymphs are 12-15mm when hatched. The time it takes for the insect to become fully mature is estimated at around 6 months, with the whole life cycle taking around 10 months. Males become adult before females.

### Defences

These insects are very docile and usually do not move when disturbed. If they become frightened they can run at great speed or exude a yellowish liquid from their mouths.

### Rearing

Bramble (*Rubus* sp.) seems to be the most successful food plant, but the insect will accept rose (*Rosa* sp.), Sweet Chestnut (*Castanea sativa*), raspberry (*Rubus ideaus*) and oak (*Quercus* sp.). These are the only plants tried.

The insects prefer to be kept warm, but will do quite well at room temperature. Newly hatched nymphs need to be kept with older insects to help them feed, but once past the 1st instar they feed well. This species should be kept moderately humid. The culture has recently been added to the Phasmid Study Group's species list as PSG 179.

### Acknowledgements

Thanks go to Barry Clarke for providing both the information and the insects, and to those who urged me to write this report!

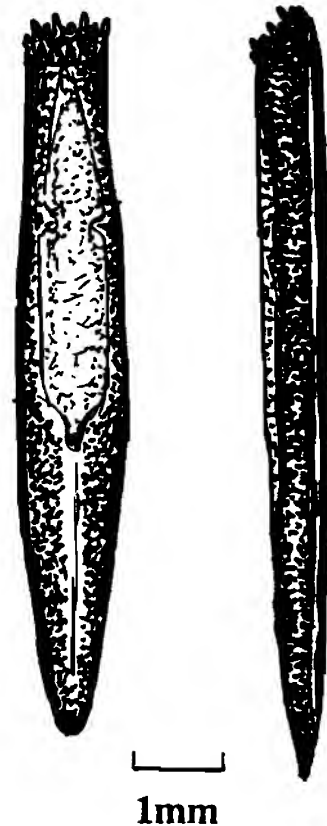


Figure 3. Egg, dorsal and lateral views.

# Parthenogenesis explained

Ewan More, 17 Blamey Crescent, Cowdenbeath, Fife, KY4 9JS, U.K.

## Abstract

The article considers the mechanism of parthenogenesis found in stick insects and the possible reasons it has developed. Reference is also made to other occurrences of parthenogenesis.

## Key words

Phasmida, Parthenogenesis, Meiosis.

## Introduction

How does parthenogenesis actually work? How widespread is it? What has actually been discovered about phasmid parthenogenesis? Does parthenogenesis affect the genetic variation of a species?

Parthenogenesis has fascinated me since I was a schoolboy. Many pupils who encounter parthenogenesis will probably do so through either the Indian stick insect, *Carausius morosus* (Sinéty), or the pink winged stick insect, *Sipyloidea sipyilus* (Westwood). Parthenogenesis is not restricted solely to phasmids. Aphids, such as greenfly, reproduce by parthenogenesis throughout the summer but in the autumn they reproduce sexually. In locusts and grasshoppers almost all the unfertilised eggs start developing, although few will develop into the adult. However it is possible to develop a parthenogenetic strain of locust (Wigglesworth, 1966) through artificial selection. Cockroaches and many species of Lepidoptera can occasionally develop from unfertilised eggs (Wigglesworth, 1966), even the familiar *Drosophila* can show parthenogenesis, *Drosophila mercatorum* having been maintained in culture for twenty years without males (Carson *et. al.*, 1982). There is even the phenomenon of parthenogenetic turkeys (Harada & Buss, 1981) although this is a bit of a dead end as all turkeys produced are male! For those who might want to look into the matter further, the explanation lies in the sex chromosomes.

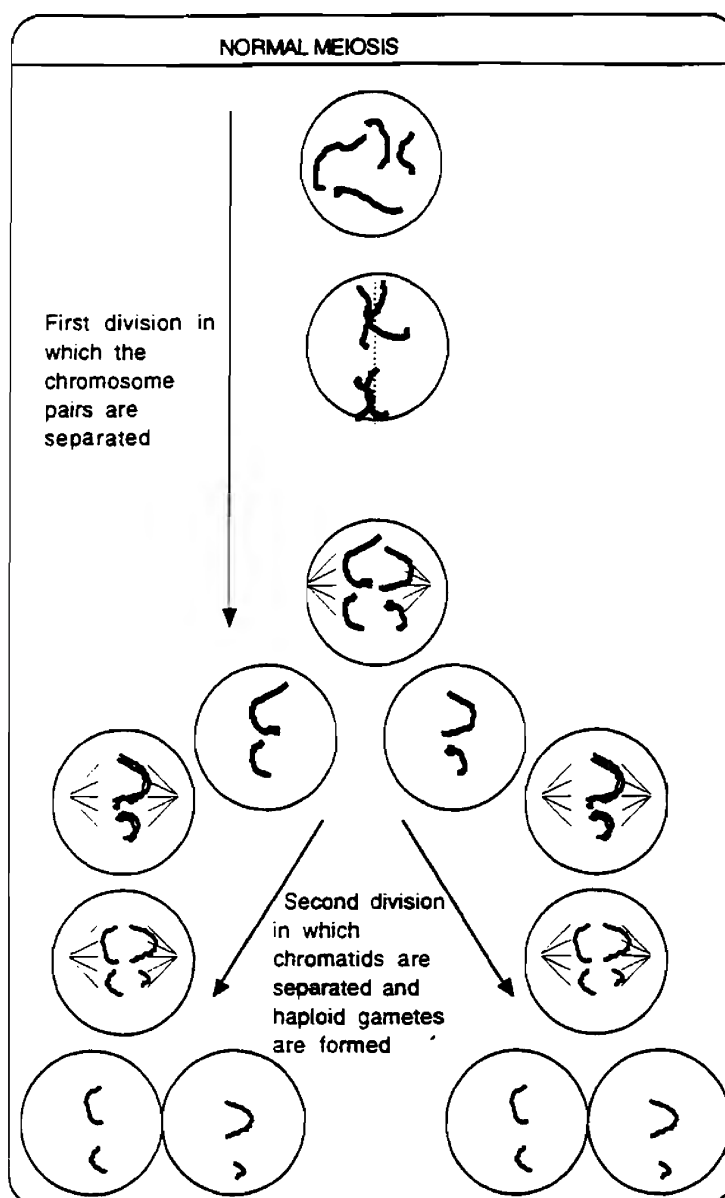
## Normal Sexual Reproduction (Meiosis)

In order to understand parthenogenesis it is necessary to first understand the normal process of sexual reproduction (see figure 1). Normal sexual reproduction uses reduction division (meiosis) to produce sex cells (gametes) with half the normal number of chromosomes. When the gametes fuse, at fertilisation, the normal chromosome number is restored. Without reduction division the chromosome number would double each time reproduction took place and the nucleus would grow until it filled the cell!

The first stage of meiotic cell division results in all the chromosomes replicating to give double the original number. However the new copy stays attached to the original and behaves as a single chromosome. The chromosomes move to form pairs (with the copy still attached), this stage is called pachytene. The pairs then move to the centre of the cell and then move to opposite poles, half to one side and half to the other, in anticipation of the cell dividing in two.

After this first division, the chromosomes line up in the centre of the cell and the chromosome copies, called chromatids, are now separated in a second division. The end result of this process, in which the cell replicates to give twice the number of chromosomes and then divides twice, is that the original cell gives rise to four gametes each with a chromosome number half that of the original ( $\times 2 \div 4 = 0.5$ ).

The difficulty for a parthenogenetic species of stick insect is to restore the normal chromosome number without fertilisation. The Indian and pink winged stick insects have 66 and 80 chromosomes respectively (Pijnacker, 1978).



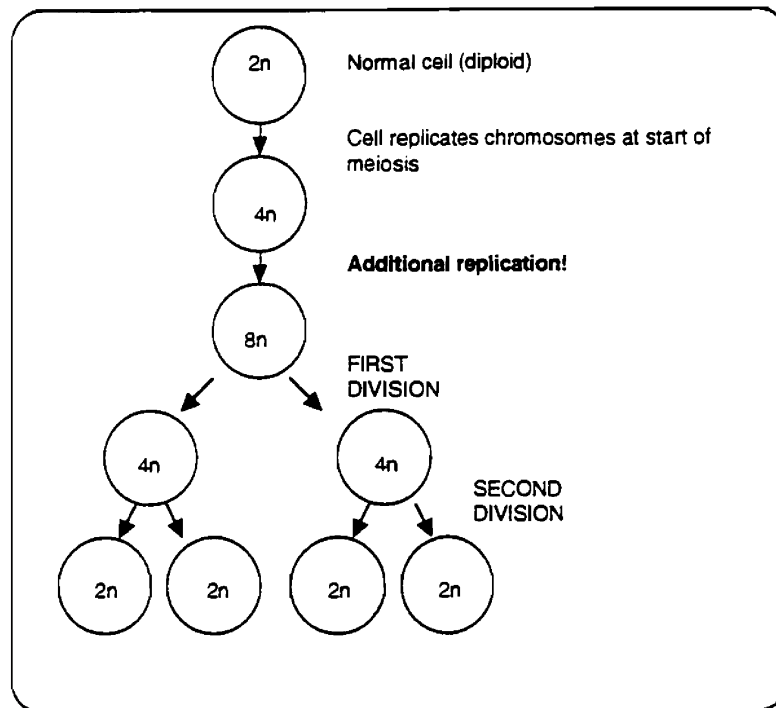
**Figure 1.** Chromosome separation during normal meiosis.

### The Mechanism of Parthenogenesis

The cultures of both the Indian and the pink winged stick insects reproduce by obligate parthenogenesis (i.e. they are forced to use parthenogenesis), although this may not be the case in the wild (see the section on the origin of *Carausius morosus*). They both use the same mechanism to accomplish reproduction without males. There is an extra replication of chromosomes following pachytene so that meiosis starts with four times the original chromosome number. As a result there are four cells with the original chromosome number after meiosis ( $x 2 \times 2 \div 4 = 1$ ). Each egg cell now has the correct number of chromosomes to divide and develops into a new stick insect (Pijnacker, 1964).

Earlier on in my studies I wondered how many eggs the meiotic divisions give rise to. Are there four viable eggs produced by the Indian stick insect? It would appear, that each cell which starts to undergo meiosis gives rise to a single egg. From Wolf's (1993: 103) comment "In a few groups, such as insects and crustaceans, no distinct polar bodies are formed. Instead, polar chromosomes are enclosed by nuclear envelopes, forming polar nuclei

that remain nonfunctional in the peripheral egg cytoplasm.", it would seem that all the meiotic events which take place, do so without the formation of separate and distinct polar bodies; this assumes that stick insects follow the same pattern as the other insects.



**Figure 2.** The parthenogenesis of *Carausius morosus*.

The eggs produced by the Indian stick insect and the pink winged are not haploid but diploid at the end of meiosis (Pijnacker, 1964 & 1978). This means that the rare males which are produced, when they mate, are trying to fertilise diploid eggs. Although mating has been observed it has no effect, indeed there is no evidence at present that sperm are transferred (Pijnacker, 1964). (see figure 2).

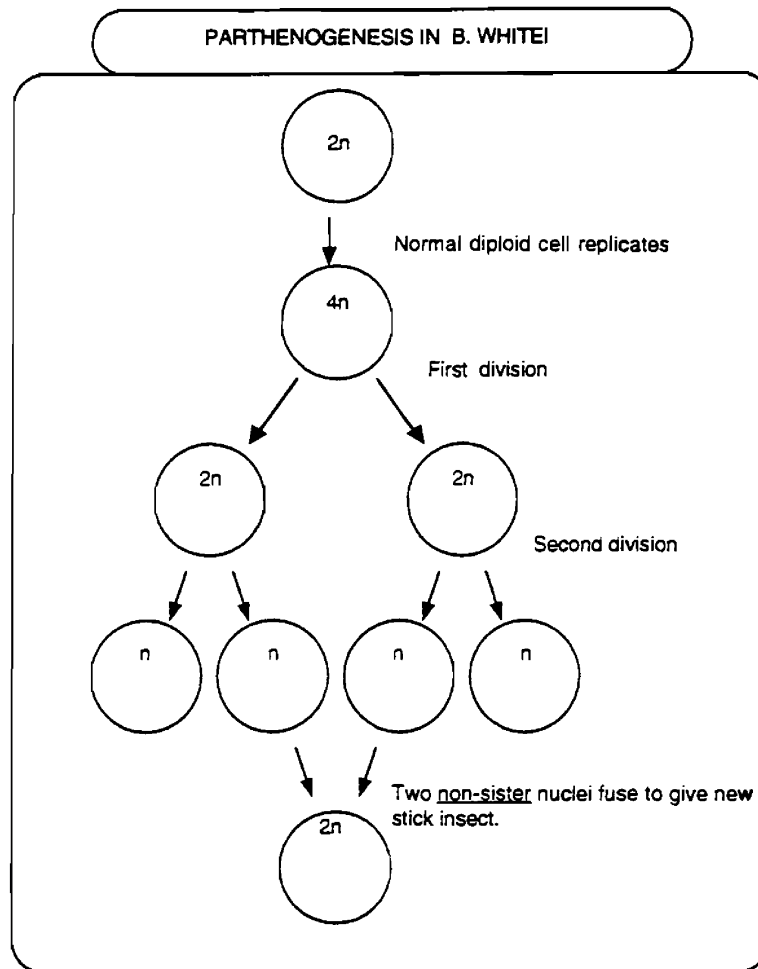
In *Bacillus whitei*, Nascetti & Bullini, the meiotic divisions occur as normal but two non-sister nuclei fuse to give a diploid egg (see figure 3). This is unsuccessful in 25% of the eggs however, which means a maximum hatching of 75% for the species (Mereschalchi *et al.*, 1991).

### The Advantage of a Modified Meiosis

Why does the process have to be so complicated? To answer that question we must be aware of two things.

The first thing to realise is that meiosis produces totipotent cells, that is cells which can divide to give a whole animal (ordinary cells produced by mitosis are unable to do this). Once the stick insect has grown to an adult, cells become locked into developmental pathways to become legs, cuticle, eyes etc. Through meiosis the cell has the potential to become all these things. Research on frogs has shown that the cytoplasm of the fertilised egg cell plays a key role in triggering the fertilised egg to divide and produce the whole frog. If the nucleus from a fertilised egg is removed and a gut cell nucleus substituted then the embryo develops normally. This shows that the cell cytoplasm, ignoring the nucleus, is primed ready to divide (Wolfe, 1993). Even unfertilised frog eggs can be triggered to start dividing by pricking the cell with a pin dipped in human blood. Somehow the mechanical and chemical stimulation





**Figure 3.** Parthenogenesis in *Bacillus whitei*.

starts cell division (Keeton, 1980). Applying this to stick insects, meiosis prepares the cell to divide and give a whole new organism; a major part of this seems to be outside the nucleus, in the cytoplasm. There is a brief discussion of the effect of the cytoplasm in embryogenesis in Siegfried Scherer's book *Typen des Lebens* (1993); he explains its significance in allowing a limited development of hybrid embryos.

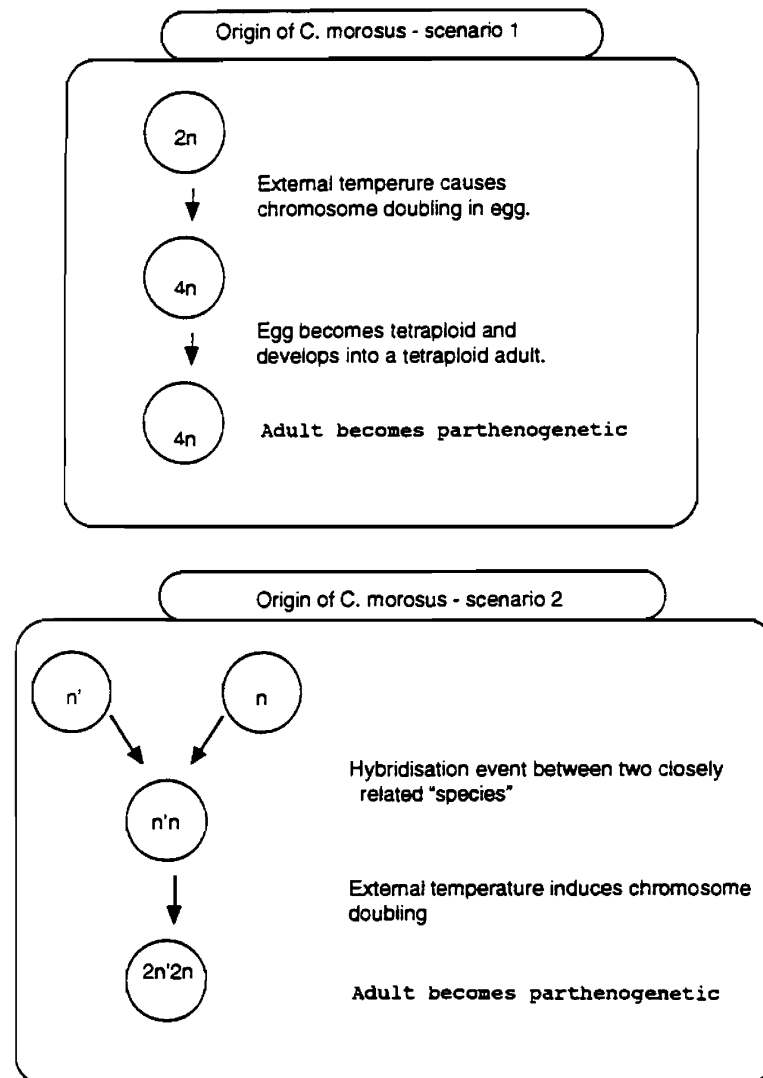
The second thing achieved by meiosis is the resetting of the "biological clock". In cells there is a mechanism on the chromosomes which permits only a given number of cell divisions. As the cell divides, small sections from the end of the chromosome are missed out. Gradually the chromosome becomes shorter and shorter. It is this which causes cells to age and lose their ability to divide. These ends, called telomeres, are restored in meiosis by an enzyme called telomerase. This effectively resets the "clock", allowing all the cell divisions necessary for the life of the organism (Crompton, 1995). An analogy in computer software is the "counter", this protects copyright by permitting only a given number of copies.

So we can appreciate that parthenogenesis needs the normal aspects of meiosis and how they prepare the cell: the telomeres are added to reset the biological clock and the cell cytoplasm is made ready to develop into a new stick insect.

### The Origin of *Carausius morosus*

A suggestion of Pijnacker (1964) is that the Indian stick insect may have arisen through

chromosome duplication. This would give rise to an autotetraploid individual: tetraploid because it would have four of each chromosome, and auto because it is an event occurring within itself which has caused the duplication.



**Figure 4.** Origin of *Carausius morosus*.

Such an individual may have been induced by cold temperatures (similar to the effects of hyperbaric pressure or heat shock treatment). That could cause chromosome doubling in the embryo. Pijnacker (1964) notes that the area where *Carausius morosus* was collected commonly has temperatures which might have a similar effect. Once fully grown it would produce eggs with twice the normal number of chromosomes (see figure 4, scenario 1).

A second possibility is that two stick insects hybridise. This could produce problems for sexual reproduction if the chromosomes could not pair properly. If an egg were to experience chromosome doubling each would have a matching chromosome to pair with. Then it could undergo meiosis and develop the extra replication which allows parthenogenesis, (see figure 4, scenario 2). This has become more likely with the discovery that *Bacillus whitei* is a hybrid of *Bacillus rossius* (Rossi) and *Bacillus grandii* Nascetti &

Bullini and that *Bacillus lynceorum* Bullini, Nascetti & Bianchi Bullini is a hybrid of *Bacillus rossius*, *Bacillus grandii* and *Bacillus atticus* Brunner (Mareschali *et. al*, 1991).

### How does Parthenogenesis Affect the Health of the Species?

Does the parthenogenesis of the stick insects lead to a homozygous individual? It is generally acknowledged that the homozygous condition shows up harmful genetic mutations which could be masked in the heterozygous condition. This is why corn, which quickly becomes homozygous through self fertilisation, shows a marked decline in vigour after several generations. Is there a similar decline in vigour of stick insects which reproduce by parthenogenesis?

In the pink winged stick insect where the fusion of non-sister polar bodies occurs we can predict the maintenance of the parental genotype with no increase in homozygosity. In the Indian stick insect (and others that show an additional replication before reduction) the heterozygosity of the mother is preserved in the daughter. So in these cases vigour should not be affected.

### Why Parthenogenesis?

Are there any advantages in parthenogenesis for the stick insect? Clark (1973) lists eleven factors associated with parthenogenesis. The most relevant are listed below (using Clark's numbering).

1. Environmental instability and the exploitation of temporary resources.
4. Reduced motility of females.
5. Infrequency of males either through genetic drift or low fitness.
6. Polyploidy, aneuploidy, male haploidy
8. Discontinuous habitats.
9. Colonising habitats.

Parthenogenetic stick insect populations are able to grow quickly because all are females. This should be compared with a sexual species where 50% are non-egg laying males. Quick population growth is an obvious advantage in transient habitats.

As regards Clarke's 5th factor, it is interesting to note that males are produced in *Carausius morosus*, however they are not virile with much less than 1% spermatozoa appearing normal (Pijnacker, 1964). For those of you who think you might have a male *C. morosus* look for the following:

- i) The male is slender and shorter than the female due to five instead of six moults.
- ii) The male chitinous skeleton appears smooth and glossy instead of matt and granular.
- iii) The male has a red mesosternum, two red stripes laterally on the mesothorax and two red spots laterally on the metanotum.
- iv) The male external genitalia consists of a single asymmetrical penis covered by an operculum which is the sternum of the ninth segment.

For the triploid *Bacillus lynceorum* with three sets of chromosomes, it could not create the chromosome pairs needed for meiosis unless it first underwent an extra replication. When it does so it then has six sets of chromosomes it then can undergo the reduction divisions of meiosis restoring it's triploid chromosome number. A similar problem is encountered by the banana: it too is triploid and because of that cannot reproduce sexually by meiosis. It is a common and widespread plant however, widely grown by the Polynesians in the Pacific. Propagation is by means of cuttings which they took with them as they colonised new islands. This is also the reason why you do not find seeds in bananas, their triploid nature means they

cannot produce seeds.

### The Occurrence of Parthenogenesis

Parthenogenesis is probably more widespread than we know. In some species parthenogenesis may be so rare that it passes unnoticed. In *Bombyx mori* only one moth was obtained from 10,000 unfertilised eggs (Engelmann, 1970). The potential for parthenogenesis has been realised for some species in the laboratory. An original bi-sexual stock of *Drosophila* has actually served as the exclusive source of four separate parthenogenetic strains isolated in 1961 and 1962 (Carson, 1982). It is not uncommon then for there to be a naturally present, low grade facultative parthenogenesis. In the wild this could be realised in two ways, one is isolation and the other is competition.

Geographical isolation could arise by individuals founding new populations in new habitats. If a few individuals with a reasonable occurrence of parthenogenesis were to colonise a new habitat females might experience difficulty in finding mates. Laying unfertilised eggs, only the parthenogenetic ones would produce adults which would obviously be females. With extremely strong selection for parthenogenesis it would not take long for a parthenogenetic race to develop. Parthenogenesis has the potential to out-compete bi-sexual races because with all the population being female they should be able to reproduce twice as quickly. Once established they would be able to out compete any sexually reproducing relatives that arrived subsequently. In genetics this would be described as a "bottleneck" or possibly "the founder effect", with a handful of specimens isolated from the rest of the population reproducing to give a new population.

In applying this to *C. morosus* we must remember that although it has been studied intensively, it is laboratory cultures which have been studied. We know that the cultures are parthenogenetic but we cannot speak so assuredly of the wild population. According to Pijnacker (1964) the original Indian stick insects seem to have been introduced to Europe about 1911 or 1912, but Ragge (1973: 229) has pointed out that there have been several importations and it has been in culture since the 1890s. It would appear to be from this original stock that all Indian stick insects have been bred.

One of the stories I heard when chasing up a report of a male Indian stick insect was that the males in the original population had died out leaving only females. If true this would have created strong selective pressures on the remaining females, in favour of parthenogenesis. If there were any noticeable differences in that original sample that may have affected their subsequent growth as a population. One of those differences in the original collection, which may have helped the spread of parthenogenesis in a "bottle-necked" population of *Carausius morosus*, may have been stick insects which could already reproduce poorly by parthenogenesis or the poor fertility of males: Clark's 5th factor.

A different pressure towards parthenogenesis has come from hybridisation and polyploidy. Hybridisation can lead to all sorts of problems during homologous pairing in meiosis, i.e. *Bacillus lynceorum* and the previously mentioned banana. In plants there is always the potential for asexual propagation by runners which can be very successful; indeed *The Guinness Book of Records* (Matthews, 1993) has a Quaking Aspen listed, which reproduced asexually by roots, to occupy 106 acres and weigh an estimated 6,000 tonnes. This is not an option for animals such as stick insects. Their equivalent is to reproduce by parthenogenesis. So, for the stick insects with mismatched sets of chromosomes (Clark's 6th factor), parthenogenesis is a their only option.

Both geographical isolation and the problems of polyploidy seem to come together in the Alps. Engelmann reports the work of Suomalainen on geographical races of the Curculionidae (Insecta: Coleoptera) in Scandinavia and the Alps. This shows a correlation

between polyploid parthenogenetic species and new habitats exposed at the end of the last Ice Age (Engelmann, 1970). It would appear that they were either better able to sustain the more adverse climatic conditions or that they followed the retreating ice and entered new habitats: Clark's 9th factor.

**Table 1.** Summary of information on the species mentioned.

PSG culture	Species	Chromosomes	Reproduction	
1	<i>C. morosus</i>	2n = 66	Parthenogenetic#	Hybrid with chromosome doubling.
4	<i>S. sipylus</i>	2n = 80	Parthenogenetic#	
108	<i>B. whitei</i>	2n = 35	Parthenogenetic*	Hybrid of No. 172 & 3.
107	<i>B. lynceorum</i>	3n = 52	Parthenogenetic#	Triploid hybrid of No. 172, 3 & 156.
172	<i>B. grandii</i>	?	Sexual	
3	<i>B. rossius</i>	?	Sexual	
156	<i>B. atticus</i>	?	Sexual	

Key: # = additional replication at start of meiosis.

\* = fusion of non sister nuclei from second meiotic division.

## Summary

That the parthenogenetic stick insects have their origins in the sexual species is clear. They can maintain their existing genetic variation (heterozygosity) but cannot add to it. Moreover such genetic variation as they possess is not available to give new combinations because each daughter has the same genotype and phenotype as her mother. On the positive side they can reproduce more quickly as an all-female race both to exploit temporary resources and colonise new habitats. Table 1 gives a summary of the information which I have been able to find about the species which I have mentioned.

## References

- Carson, H.L., Chang, L.L. & Lyttle, T.W. (1982) Decay of Female Sexual Behaviour Under Parthenogenesis. *Science*, **218**: 68-70.
- Clark, W.C. (1973) The Ecological Implications of Parthenogenesis. Pages 103-112 in: *Perspectives in Aphid Biology*, Caxton Press, Christchurch, New Zealand.
- Crompton, N. (1985) Molecular Biology of Aging. Lecture delivered at *Kontakt der Kontinenten*, Amersfoort. (Copies available).
- Engelmann, F. (1970) *The Physiology of Insect Reproduction*. Pergamon, Oxford.
- Harada, K. & Buss, E.G. (1981) The Chromosomes of the Turkey Embryos During Early Stages of Parthenogenetic Development. *Genetics*, **98**: 335-345.
- Keeton, W.T. (1980) *Biological Science*. W.W. Norton and Company, Toronto, Canada, p. 698.
- Marescalchi, O., & Pijnacker, L.P. & Scali, V. (1991) Cytology of parthenogenesis in *Bacillus Lynceorum*. *Invertebrate Reproduction and Development*, **20**: 75-81.
- Matthews, P. (1993) *The Guinness Book of Records 1994*. 40th Edition. Guinness Publishing, London.
- Pijnacker, L.P. (1964) The cytology, sex determination and parthenogenesis of *Carausius morosus* (BR.) Thesis, University of Groningen.
- Pijnacker, L.P. & Ferwerda, M.A. (1978) Additional chromosome duplication in female meiotic prophase of *Sipylodea sipylus* Westwood (Insecta, Phasmida) and its absence in male meiosis. *Experimentia*, **34**: 1558-1560.
- Ragge, D.R. (1973) The British Orthoptera: a supplement. *Entomologist's Gazette*, **24**: 227-245.
- Scherer, S. (1993) *Typen des Lebens*. Weichert Druck, Darmstadt.
- Wigglesworth, V.B. (1966) *The Life of Insects*. Weidenfeld and Nicholson, London.
- Wolfe, S.L. (1993) *Molecular and Cellular Biology*. Belmont, California.



# Reviews and Abstracts.

## Meeting / Conference Reports

### **The Second International Meeting on Phasmatodea** - Report by John Sellick.

This second meeting was as near as possible to the tenth anniversary of the First International Symposium on Phasmatodea which was held at Pontignano near Siena, Italy in October 1986. The first symposium had been a three day residential gathering at which some 27 papers had been presented. The second meeting was limited to four hours and was held on 27th August 1996 within the confines of the 20th International Congress of Entomology in Florence. Seven papers were presented but there are no plans to publish the proceedings of the meeting. The seven papers were:

The range of egg capsule morphology within the Phasmatodea and its relevance to the taxonomy of the order. J.T.C. Sellick.

The role of vitellophages during yolk utilization in stick insect embryos. A.M. Fausto, M. Mazzini, & F. Giorgi.

Genomic DNA analysis of parental and hybrid *Bacillus* stick-insects (Phasmatodea). 70. Mantovani, & F. Tinti.

Vitellin processing in ovarian follicles and in embryos of *Carausius morosus* (Br.) (Phasmatodea: Lonchodinae). M. Masetti, A. Ceccettini, M.T. Locci, & F. Giorgi.

Egg maturation and development in hemiclinal and clonal hybrids of *Bacillus* stick insects. L.P. Pijnacker, O. Marescalchi, & F. Tinti.

The genus *Sipyloidea* Brunner in Australia (Phasmatodea: Phylliidae: Necrosiinae). D.C.F. Rentz.

*In situ* hybridization of highly repetitive DNA in *Bacillus* stick insects: Cytotaxonomy and genome evolution. F. Tinti, & V. Scali.

## Book Review

**Grasshopper country: the abundant orthopteroid insects of Australia** by David C.F. Rentz (1996). Published by University of New South Wales Press, Sydney. Hardback, xi + 284 pages, 425 colour photos, numerous black-and-white photos and figures. ISBN 0-86840-063-7. Price £42.00. - Reviewed by Paul Brock.

This beautifully illustrated and well designed volume, with an attractive dust jacket, covers all Australian orthopteroid insects. In addition to a very informative text from a world renowned expert, there are 425 colour and 150 black-and-white photographs, nearly all taken by the author in the field or in the laboratory. A range of good quality figures is also included.

Part one (pages 1-45) contains several introductory sections: basic characteristics, taxonomy, conservation, "singing" orthopteroids, mating and courtship, collecting, rearing, killing, and preserving the colourful Australian fauna.

Part two (pages 46-208) covers the Orthoptera: grasshoppers, katydids, and crickets, which are split into the respective groups. Part three (pages 209-257) covers the remaining orthopteroid orders: cockroaches, mantids, and phasmids. Keys to subfamilies, tribes and/or genera are provided, along with sketches showing key anatomical characters. The text takes into account relevant research and includes useful notes on culture methods, classification, preservation, behaviour, distribution, and foodplants, along with remarks on representative species within families. Pages 258-284 includes sections dealing with photography, special

interest groups, formulas and recipes, a brief glossary, references, and an index.

To elaborate on the phasmid section, the PSG is given an excellent write-up (thanks David!) and the main section on phasmids (pages 244-257) is an excellent introduction to Australian species, with 10 figures illustrating eight species and the eggs of 13 species. An introduction includes notes on species which can reach high populations with phase differences in colour. The reader may also learn that a *Megacrania* species squirts a milky substance smelling of peppermint at intruders when it is annoyed. Brief sections which follow discuss identifying features, economic importance, collecting techniques, culture methods, preservation and classification: these offer useful advice or point to key references. The text on representative species within subfamilies is valuable, with the author highlighting taxonomic difficulties, indeed some undescribed species are referred to only by genus. The outstanding colour photographs (main phasmid section: plates 402-425 which illustrate 18 species) range from the striking underside of *Eurycnema goliath* to the broad-winged *Tropidoderus childrenii*, a spectacular species yet to be successfully cultured in Europe. One of the most remarkable transformations in the phasmid world must be the final moult in the male of *Nanophyllium pygmaeum*, a small leaf insect which is illustrated on plates 402 (nymph) and 403 (adult); one would expect a broad leaf-like insect to emerge from the final moult, not the wasp-like insect which is only recorded from Katau in Papua New Guinea (the type locality) and Australia: near Iron Range National Park in NE Queensland (I have recently acquired an adult male from Nabire in Irian Jaya).

What more can the orthopterist or phasmid enthusiast want than this highly accurate, colourful volume. David Rentz has included invaluable observations from his collecting trips across Australia and the outstanding plates show numerous species, including their behaviour, mating, moulting, and camouflage. This attractively priced book will also cater for readers interested in nature or general entomology; save up for this book, or order it from a library. I can do no better than sum up with an accurate statement from the dust jacket: "*Grasshopper country* is one of the most comprehensive and best illustrated books on orthopteroid insects anywhere in the world, and a milestone in Australian entomology".

The book comes with an audio CD of sounds from 130 species. Available from CSIRO Publishing, PO Box 1139, Collingwood, Victoria 3066, Australia. Price US\$ 79.95 (all major credit cards accepted). It is also available from some UK retailers.

## Phasmid Abstracts

The following abstracts briefly summarise articles which have recently appeared in other publications; also included are publications published since 1992 (the first issue of *Phasmid studies*) which have only recently come to the attention of the editor. Some of these may be available from local libraries. Others will be available in university or college libraries, many of these libraries allow non-members to use their facilities for reference purposes free of charge. In the UK libraries can usually obtain publications which they do not hold by using the inter-library loan system; there is usually a charge for this service. A similar inter-library loan system operates in many other countries.

The editor of *Phasmid Studies* would welcome recent abstracts from authors so that they may be included in forthcoming issues. In the case of publications specialising in phasmids, *Phasma* and *Le Monde des Phasmes*, only the longer papers are summarised.

**Bi, D.Y.** (1995) Description of three new genera and three new species of Phasmatodea from Xizang, China (Phasmida: Pseudophasmatidae, Heteronemiidae). *Acta Entomologica Sinica*, **38**(4): 452-457. [in Chinese]

In the present paper, three new genera and three new species from Xizang, China, are described. All the type specimens are deposited in Shanghai Institute of Entomology, Academia Sinica.

*Leurophasma* gen. nov. This new genus closely allied to *Aschiphasma* Westwood, but is chiefly distinguished by both the anterior-lateral margins of pronotum with very narrowed elliptic furrow. The body without tegmina and wings. Type-species: *Leurophasma dolichocerca* sp. nov.

*Leurophasma dolichocerca* sp. nov. (figs. 1-7). Body smooth, without any granules, apterous, stick-like. Antennae long, reaching much beyond the base of the hind femora. Both the anterior-lateral margins of pronotum with very narrowed elliptic furrow, mesonotum longer than metanotum, metanotum longer than the width, median segment longer than metanotum and united with it. Tarsi 5-segmented, claws finely pectinate. Margins of abdomen without lateral outgrowths, anal segment of male not split and bilobed. Subgenital operculum of female comparatively shorter, with the apical margin broadly rounded, not exceeding the middle of anal segment. Holotype male, allotype female, paratypes 2 females, Medog, Xizang. 18-21.vii.1979.

*Megalophasma* gen. nov. This new genus is allied to *Parasosibia* Redtenbacher, but differs in the occiput with varying sizes of distinct big or small granules. The subgenital operculum of female scoop-like, without granules, but on the ventral surface with median carina and hairs, the apical margin narrowly rounded and never pointed. Type-species: *Megalophasma granulata* sp. nov.

*Megalophasma granulata* sp. nov. (figs. 8-11). Body stout and robust, apterous, granulated. Head rather flat, a little broader than the pronotum, occiput with varying sizes of distinct big or small granules. Antennae long, nearly reaching to the apex of the front legs. Mesonotum longer than metanotum. The subgenital operculum of female not exceeding the supra-anal plate, scoop-like, without granules, but on the ventral surface with median carina and hairs, the apical margin narrowly rounded and never pointed. Male unknown. Holotype female, paratypes 6 females, Medog, Xizang; 18.vii.1980.

*Arthminotus* gen. nov. This new genus is allied to *Paramyronides* Redtenbacher, but is easily distinguished from that by the median segment entirely fused with metanotum together, the hind legs comparatively long, exceeding the apex of abdomen. Type-species: *Arthminotus sinensis* sp. nov.

*Arthminotus sinensis* sp. nov. (figs. 12-14). Body elongate and long, apterous, smooth, non-granulated. Head distinctly longer than the width. Antennae long, distinctly longer than the length of the front legs, backwardly exceeding the base of the hind femora. Mesonotum long, distinctly longer than the pronotum and metanotum (with median segment) together, median segment entirely fused with metanotum together, transverse sulcus invisible. The hind legs comparatively long, exceeding the apex of abdomen. The last two tergites of abdomen together slightly longer than the preceding tergite. The hind margin of the last tergite of abdomen slightly emarginated at the median carina. Subgenital operculum very slightly cymbiform, apex sharply pointed, nearly as long as the three apical tergites, but not reaching to the hind margin of the anal-segment. Male unknown. Holotype female, paratype female, Medog, Xizang; 5.vii.1980.

**Bragg, P.E.** (1996) Type specimens of Phasmida in Leiden Museum (Insecta: Phasmida). *Zoologische Mededelingen Leiden*, 70: 105-115.

Type specimens of 75 taxa of Phasmida have been identified in the Nationaal Natuurhistorisch Museum, Leiden. The taxa are listed alphabetically by species, with the number of specimens, sex and locality data. The material includes species described by Bragg, Bragg and Chan, Günther, de Haan, Kirby, Lichtenstein, Olivier, and Stoll. The type of pin used was found to be particularly useful as an aid to identification of older material.

There are a number of omissions and discrepancies in the published data, these are clarified. Some background information on the original publications and the described material is included.

**Brock, P.D.** (1996) Hot insect collecting. *Insect World International*, 1(4): 14-15.

Notes on the author's 1994 collecting trip to Darwin Australia and Peninsular Malaysia. With colour photographs of collecting near a bush fire, *Eurycnema cercata* Redtenbacher startle display, *Presbistus horni* (Redtenbacher), and *Datames oileus* (Westwood).

**Camousseight, A.** (1995) Taxonomic review of the genus *Agathemera* (Phasmatodea: Pseudophasmatidae) in Chile. *Revista Chilena de Entomologia*, 22: 35-53. [in Spanish]

*Agathemera* Stål 1875, is an endemic Pseudophasmatidae genus from southern South America. This revision includes a key and a systematic study of the Chilean species: *A. crassa* (Blanchard), *A. grylloidea* (Westwood), *A. elegans* (Philippi) and *A. claraziana* (Saussure). Two new species are described: *A. maculafulgens* and *A. mesoauriculae*. All species are illustrated. *Agathemera anthracina* Redtenbacher is a junior synonym of *A. elegans*.

**Chan, C.L.** (1996) Walking sticks and flying leaves - stick and leaf insects of Borneo. *Borneo Magazine*, 2(1): 26-37.

A general article on phasmids, concentrating on species from Borneo. *Varinus* sp. is recorded as a predator of *Haaniella* sp. With 12 colour photographs (including the cover illustration) of species from Borneo and West Malaysia.

**Chen, S. & He, Y.** (1992) Phasmida. In: Peng, J. & Lui, Y. [eds.] *Iconography of forest insects in Hunan China*. Academia Sinica & Huan Forestry Institute, Huan, China. 1473 pages. [Phasmida: pages 42-49]. [in Chinese]

Nineteen species of Phasmida are recorded and illustrated. Six new species are described and illustrated: *Baculum asaphum*, *Baculum rotundum*, *Baculum sparsidentatum*, *Oxyartes varius*, *Phraortes brevipes*, *Phraortes speciosus*. The English summary (pages 48-49) gives brief descriptions and measurements of the new species.

**Chen, S.C. & He, Y.H.** (1995) A new species of the genus *Paramyronides* from Yunnan, China (Phasmatodea: Heteronemiidae). *Forest Research*, 8(6): 658-659. [in Chinese]

This paper deals with a new species of the genus *Paramyronides* collected from Yunnan Province, China. The type specimens are deposited in the Insect Collection of Institute of Zoology, Academia Sinica and Beijing Forestry University. All the measurements are in millimetres. *Paramyronides yunnanensis* sp. nov. resembles *P. porus* but differs from the latter in the following characters: fore wings absent, posterior margin of anal segment emarginate deeply, its posterior lateral lobes pointed, straight and distant from each other. Body 80.3; pronotum 3.2; mesonotum 19.4; metanotum (with median segment) 10.2; median segment 2.8; fore femur 25.0; middle femur 18.0; hind femur 24.5. Female: unknown. Holotype male, paratype 1 male, Xishuangbanna, Yunnan Province, 9.ix.1993, 16.ix.1993, collected by Yang Longlong and Cheng Xinyao.

**Chen, S.C. & He, Y.H.** (1995) A new species of the genus *Baculum* Saussure from Guangxi Province (Phasmida: Phasmatidae). *Acta Entomologica Sinica*, 38(4): 458-459. [in Chinese]

The present paper describes a new species of walking stick, which was collected from Longsheng of Guangxi Province. The type specimen is preserved in the Insect Collection of



Beijing Forestry University. All measurements in descriptions are in mm. *Baculum obliquum* sp. nov. is allied to *Baculum inversecornutum* Brunner, it differs from the latter species in: (1) The spines of head protrude forward; (2) The externo-inferior carina of front femora with a row of teeth; (3) Four posterior femora with many teeth nearly throughout on the externo-inferior and interno-inferior carina; (4) The posterior margin of the anal segment incised deeply. Body 182.6; pronotum 4.6; mesonotum 35.8; metanotum (with median segment) 27.4; median segment 4.4; abdomen 98.6; 1st tergite 11; ninth tergite (= anal segment) 5.4; operculum 25.4; front femora 49; middle femora 36.5; hind femora 38. Male: unknown. Holotype female, paratype 1 female, Longsheng County, Guangxi. 9.viii.1986, Chen Shuchun leg.

**Cruse, H., Brunn, D.E., Bartling, C., Dean, J., Dreifert, M., Kindermann, T. & Schmitz, J. (1995)** Walking: A complex behavior controlled by simple networks. *Adaptive Behavior*, 3(4): 385-418.

Understanding how behaviour is controlled requires that modelling be combined with behavioral electrophysiological, and neuroanatomical investigations. One problem in studying motor systems is that they have considerable autonomy, they are not driven solely by inputs. Choosing walking as the object of study is promising because it is a comparably simple and easy-to-elicited behaviour, but it exhibits the special feature of most motor behaviour - the interaction between central autonomous components and peripheral, sensory influences. This article reviews the control of walking in stick insects, beginning with behavioral studies of single-leg control and the interleg coordinating mechanisms. These behavioral results are tested and supported by modelling the control system in an artificial neural network computer simulation and a six-legged robot. Supporting neurophysiological results also are considered. Together the results indicate that the high flexibility and adaptability is based on a simple distributed control structure.

**Delfosse, E. (1996)** Attention aux parasites qui parasitent les idées ou à ceux qui ont parasité un phasme. *Le Monde des Phasmes*, 33: 7-9.

The author discusses the dead phasmid found by C. Brasse (*Le Monde des Phasmes*, 30: 41) and questions whether it was really parasitised by an ichneumon fly. It is suggested that it was not a true ichneumon fly but a member of the Braconidae.

**Delfosse, E. (1996)** Cannibalisme et réflexions sur les phasmes commettant des "erreurs". *Le Monde des Phasmes*, 34: 14-16.

Discusses cannibalism in *Phyllium* spp., *Sipylodea sipylus*, and *Extatosoma tiaratum* and the effects of stress.

**Dorel, E., Lelong, P., & Deschandol, A. (1996)** *Baculum thaili* Hausleithner, 1985, PSG n°. 22. *Le Monde des Phasmes*, 35: 13-15.

A report on the rearing of *Baculum thaili* Hausleithner, from Thailand. With illustrations of the adults and egg.

**Driesang, R.B. & Bueschges, A. (1996)** Physiological changes in central neuronal pathways contributing to the generation of a reflex reversal. *Journal of Comparative Physiology A Sensory Neural and Behavioral Physiology*, 179(1): 45-57.

1. In the stick insect *Carausius morosus* the properties of the neuronal network governing the femur-tibia joint depend on the behavioral state of the animal. In the inactive animal flexion of the femur-tibia joint results in the generation of a resistance reflex, while



in the active animal the same stimulus induces the so-called active reaction, the first part of which is a reflex reversal.

2. Recordings from motoneurons innervating the extensor tibiae muscle indicated that their time course of activity during the active reaction is due to inputs from intercalated pathways. They therefore investigated the role of identified nonspiking interneurons that transmit sensory information from the chordotonal organ onto the extensor motoneurons in the inactive animal. They can show that (i) the nonspiking interneurons received altered inputs whereas (ii) they provided qualitatively the same synaptic drive onto leg motoneurons.

3. From the results it is clear that (i) neuronal pathways contributing to the generation of the resistance reflex are also involved in the generation of the reflex reversal in the same control loop, (ii) thereby adopting the same principle of information processing (parliamentary principle), because both, supporting and opposing pathways contribute to the generation of the motor output.

**Gorkom, J. van** (1996) Enige notities over PSG 173: *Menexenus maerens*. *Phasma*, **6**(22): 5-8.

Report on rearing PSG 173, *Menexenus maerens* Brunner, a sexual culture from Vietnam. Includes a drawing of the egg and colour photographs of the male and the female.

**Gorkom, J. van** (1996) PSG no. 85: *Paraphasma rufipes* (Redtenbacher, 1906). *Phasma*, **6**(22): 15-16.

A report on rearing PSG 85, *Paraphasma rufipes* (Redtenbacher). The culture is parthenogenetic and is derived from material collected in Peru by Didier Mottaz in September 1984. Includes a drawing of the egg and a colour photograph of the female.

**Gorkom, J. van** (1996) De roodknietak en de oranjeknietak. *Phasma*, **6**(23): 20-21.

Brief notes, and colour photographs of two colour forms of the male of *Carausius sanguineoligatus* Brunner. The typical red-kneed form is from Mt Kinabalu in Sabah, the orange-kneed form is from Loksado in Kalimantan.

**Hennemann, F.** (1996) PSG 89: De mindorotak, een nog ongeïdentificeerde soort van de onderfamilie Necrosiinae. *Phasma*, **6**(22): 1-5.

Report on rearing PSG 89, an unidentified species of Necrosiinae. Includes drawings of the male, female and egg. This is a Dutch translation of *Phasmid Studies*, **4**(2): 67-69.

**Kwon, Y.J., Ha, J.S. & Lee, C.E.** (1992) Classification of the order Phasmida from Korea. *Nature and Life*, **22**(2): 43-58. [in Korean]

All the known species of the order Phasmida from Korea are revised and arranged here. A total of five species belonging to three genera under three families are treated, of which one species is new to science: *Baculum koreanus*. Keys, synonymic lists, host plants and distributional data for each species are provided. The paper includes a distribution map, and photographs of the adults and eggs, for each species.

**Langlois, F.** (1996) L'oeuf de *Craspedonia gibbosa* (Burmeister, 1838). *Le Monde des Phasmes*, **35**: 3-8.

Describes the egg of *Craspidonia gibbosa* (Burmeister) from French Guiana and illustrates it with 8 SEM photographs.

**Langlois, F. & Lelong, P.** (1996) Catalogue des Phasmes des Antilles. *Le Monde des Phasmes*, **35**:20-26.

A catalogue of phasmids from the Antilles.

[Editor's note: Although a long bibliography is given, there is no reference to C.F. Moxey's PhD thesis: *The stick insects of the West Indies - their systematics and biology*, Harvard University, 1972 (unpublished).]

**Langlois, F. & Lelong, P.** (1996) Cartographie des phasmes français. *Le Monde des Phasmes*, **35**: 27-29.

Distribution maps of the three species of French phasmids: *Bacillus rossius*, *Clonopsis gallica*, and *Leptynia hispanica*.

**Lee, M.** (1996) Etude sur la distribution des phasmes en Grande-Bretagne (deuxième partie et fin). *Le Monde des Phasmes*, **33**: 10-15.

The second and final part of the translation of the author's paper "A survey into the distribution of the stick insects of Britain" from *Phasmid Studies*, **4**(1): 15-23.

**Lelong, P.** (1996) Le dictionnaire des Phasmes (suite). *Le Monde des Phasmes*, **33**: 16-26.

Illustrations and French terminology used to describe the parts of the thorax and limbs of phasmids.

**Lelong, P.** (1996) Le dictionnaire des Phasmes (suite). *Le Monde des Phasmes*, **34**: 17-25.

Illustrations and French terminology used to describe the genitalia of phasmids.

**Mantovani, B., Tinti, F. & Scali, V.** (1995) Genetic structure and similarity relationships of the unisexual cyprian *Bacillus* (Insecta Phasmatodea). *Biologisches Zentralblatt*, **114**(3): 299-306.

The allozymic analysis of newly collected specimens of *Bacillus cyprius* Uvarov - morphologically described in 1936 on a single female from the Isle of Cyprus - indicates that they belong to the *B. atticus* complex. The analysis of the Cyprian *Bacillus* has revealed 5 new zymotypes and a level of polymorphism comparable to that found in the diploid *B. a. atticus* and in the diplo-triploid *B. a. carius*. Nei's, genetic distances suggest a higher affinity with the Italian, Croatian, and Greek diploid demes, than with the geographically closer Turkish ones. Body and egg morphology and karyological features seem to support a subspecific differentiation for the new taxon, which we refer to as *B. a. cyprius*.

**Paris, M.** (1994) Catalogo de tipos de Orthopteroides (Insecta) de Ignacio Bolívar, I: Blattaria, Mantodea, Phasmoptera y Orthoptera (Stenopelmatoidea, Rhamphidophoroidea, Tettigonioidea, Grylloidea, Tetrigoidea). *Eos*, **69**: 143-264.

The type specimens of the species of Blattaria, Mantodea, Phasmoptera, Stenopelmatoidea, Rhamphidophoroidea, Tettigonioidea, Grylloidea and Tetrigoidea described by Ignacio Bolívar have been catalogued. They are deposited in the Museo Nacional de Ciencias Naturales (Madrid) and in other institutions, mainly European, as well. Bolívar described 119 taxa of specific or infraspecific level in Blattodea, 37 in Mantodea, 31 in Phasmoptera, 12 in Stenopelmatoidea, 5 in Rhamphidophoroidea, 276 in Tettigonioidea, 137 in Grylloidea and 211 in Tetrigoidea, and the type series of 95, 27, 21, 11, 5, 218, 123 and 192 of them have been located, respectively. The original reference, type category, label and preservation data for each specimen, depositories, and present taxonomic status are given for each taxon. Lectotypes are designated for 7 taxa of Blattaria, 3 of Mantodea, 1 of

Phasmoptera, 1 of Stenopelmatoidea, 1 of Rhamphidophoroidea, 45 of Tettigonioidea, 13 of Grylloidea and 39 of Tetrigoidea. Previous lectotype designations for *Loboptera maroccana*, *Ephippigera martinezii*, *Criotettix exertus*, *C. flavopictus*, and *Systolederus greeni*, and neotype designation for *Meterioptera sabulosa indecisa* are not considered to be valid. *Phyllodromica ignabolivari* Bohn, 1993 is synonymised with *Phyllodromica panteli* (Bolívar, 1921) (objective synonyms). The name *Phyllodromica horstbohni* sp.n. is proposed for *Phyllodromica panteli*, *sensu* Bohn, 1993 (*non* Bolívar, 1921). Finally, a list of 34 specific names of taxa in the superfamily Tetrigoidea, never described by Bolívar, are included.

**Ravat, P.** (1996) Chaleur et humidite (Aménagement d'un terrarium). *Le Monde des Phasmes*, **34**: 8-9.

Describes and illustrates a phasmid cage designed to maintain a suitable humidity and temperature for rearing *Phyllium* spp.

**Ravat, P.** (1996) Un cas de nanisme chez *Acrophylla wuelfingi*. *Le Monde des Phasmes*, **34**: 11-13.

Discusses and illustrates an example of arrested development in *Acrophylla wuelfingi*.

**Roget, J.** (1996) Elevage de *Haaniella dehaani* (Westwood, 1859) PSG No 126. *Le Monde des Phasmes*, **33**: 3-6.

A report on rearing *Haaniella dehaanii*. Eggs take 8-9 months to hatch, nymphs take 8-10 months to reach adult, and adults live for 16-20 months. First instar nymphs may be sexed by examination of the tip of the abdomen. The adult male and female are illustrated as are the abdomens of a first instar male and female, and a dorsal view of the egg.

**Sandoval, C.P.** (1994) The effects of the relative geographic scales of gene flow and selection on morph frequencies in the walking-stick *Timema cristinae*. *Evolution*, **48**(6): 1866-1879.

Gene frequencies in large populations are determined by a balance between selection and gene flow between neighbourhoods of different selection regimes. This balance is affected by the area of the patches of a given selection regime relative to the gene-flow distance. If patches are small relative to gene-flow distance, similarity in the total area occupied by different patch types is a crucial condition for the stability of polymorphisms. However if patches are larger than the gene-flow distance, then the relative area of different patch types is less important because of reduced gene flow resulting from isolation by distance. Two morphs (striped and unstriped) of the walking-stick *Timema cristinae* were each strongly associated with patches of distinct species of food plants on which they are most cryptic. The frequency of a morph was high on the plant on which it is most cryptic when either: (1) the area occupied by the food plant (patch) was very large; (2) the patch was completely isolated from other patches; or (3) the patch was larger than adjacent patches. Results (1) and (2) are consistent with isolation-by-distance models, and result (3) is consistent with Levene's multiple-niche polymorphism model.

**Sandoval, C.P. & Vickery, V.R.** (1996) *Timema douglasi* (Phasmoptera: Timematodea), a new parthenogenetic species from southwestern Oregon and northern California, with notes on other species. *Canadian Entomologist*, **128**(1): 79-84.

*Timema douglasi* sp.nov. is described from Southwestern Oregon and northern California, USA. The head, pronotum abdominal terminalia and egg are illustrated. It is the third Parthenogenetic species in the genus and is a specialist feeder on old-growth Douglas

fir, occasionally causing serious defoliation. *Timema knulli* Strohecker is synonymized with *Timema californicum* Scudder.

**Schmitz, J., Bartling, C., Brunn, D.E., Cruse, H., Dean, J., Kindermann, T., Schumm, M. & Wagner, H.** (1995) Adaptive properties of "hard-wired" neuronal systems. *Verhandlungen der Deutschen Zoologischen Gesellschaft*, **88**(2): 165-179.

A system that controls the leg movement of an animal or a robot walking over irregular ground has to ensure stable support for the body and at the same time to propel it forward. To do so, it has to react adaptively to unpredictable features of the environment. We present here a model for the control of leg movement of a 6-legged walking system. The model is based on biological data obtained from the stick insect. The complete system contains no variable weights, so it can be considered as "hard-wired". Nevertheless, it can adapt in several ways to changes in the environment. It shows high stability against noise in the selector net, changes of the anterior extreme position (AEP) and the posterior extreme position (PEP), and disturbances during the swing movement. The system can adapt the body height to uneven substrates. It can adapt to different walking speeds and changes in walking direction. It can successfully cope with a high percentage of randomly chosen starting positions. Finally, the use of positive feedback during stance provides automatic adjustment for flexible substrate and for unpredictable changes in the geometry of the system, such as changes in leg length or soft suspension of joints.

**Seow-Choen, F. Seow-En, I. & Seow-An, S.** (1996) Colour in stick and leaf insects. *Nature Malaysiana*, **21**(2): 40-47.

A brief general discussion of defence in phasmids, with 17 colour photographs of phasmids from West Malaysia and Australia.

**Tinti, F. & Scali, V.** (1996) Androgenetics and triploids from an interacting parthenogenetic hybrid and its ancestors in stick insects. *Evolution*, **50**(3): 1251-1258.

Populations of unisexual organisms are often assumed to be genetically invariant (clones) and destined to a short existence on an evolutionary time-scale. Unisexual organisms are most often obligate parthenogens and, by definition, ought to be completely isolated reproductively from related bisexual organisms. The assumption of complete reproductive isolation between amphimictic ancestors and thelytokous hybrids is common to most hypotheses on the evolution of sex and its adaptive significance. Stick insects of the genus *Bacillus* however provide evidence for reproductive interactions between allodiploid parthenogens and their ancestors, because pure species progeny (androgenetics) and triploid descendants are produced. These findings demonstrate that, through androgenesis, offspring of parthenogenetic hybrid females can contribute specimens of both sexes to the fathering species when fertilized by syntopic ancestral males and the parthenogenetic egg of strictly clonal females, when fertilized, allows a third genome to be added to the allodiploid chromosome set. These triploid genomes promote further genetic diversification and evolution of the unisexual populations through the formation of new clones by recombination during the changed maturation mode of allotriploid eggs. All this argues for much more complex breeding systems and evolutionary pathways than are usually assumed for hybrid unisexual organisms.

**Tay, E.P. & Seow-Choen, F.** (1996) Relationship of plant families and stick-insects in Peninsular Malaysia and Singapore. In: Turner, I.M., Diong, C.H., Lim, S.S. & Ng, P.K.L. [Editors], *Biodiversity and the dynamics of ecosystems*. DIWPA Series, **1**: 181-190.



Forty-two species of phasmids in Peninsular Malaysia and Singapore and their known natural foodplants and foodplants for rearing phasmids in captivity are discussed. While the majority of the species feed on dicotyledonous plants, a few phasmid species of the subfamily Heteropteryginae also feed on monocotyledonous plants.

**Tuccini, A., Maida, R., Rovero, P., Mazza, M. & Pelosi, P. (1996)** Putative odorant-binding protein in antennae and legs of *Carausius morosus* (Insecta, Phasmatodea). *Insect Biochemistry and Molecular Biology*, 26(1): 19-24.

A 19 kDa protein has been purified by gel filtration and anion-exchange chromatography from the antennae of *Carausius morosus*. Its amino terminal amino acid sequence shows significant similarity (30% identity) with another putative odorant-binding protein, the so called OS-D protein isolated from the antennae of *Drosophila melanogaster*; only 20% of its amino acids are shared with some members of Lepidoptera pheromone-binding proteins. Polyclonal antibodies, raised against a synthetic amino terminal peptide cross-react with 19 kDa band in the legs extracts, but not with soluble proteins from other parts of the body. The amino terminal sequence of this protein, purified from the legs was identical with that of the antennae protein.

**Zompro, O. (1996)** Zum Sammeln, Transport, Konservieren und Züchten von Phasmiden. *Entomologische Zeitschrift*, 106(5): 194-202.

Methods of collecting, transporting, preserving and culturing Phasmatodea are described.

## Publications noted

The following publications have been noted but no abstract has been received.

**Frantsevich, L. & Frantsevich, L. (1996)** Space constancy in form perception by the stick insect. *Naturwissenschaften*, 83(7): 323-324.

## Erratum

*Phasmid Studies* volume 5(1): 41, figure 24

The editor regrets that the wrong illustration was printed. The shape of the egg is correct but the micropylar plate should not extend beyond the micropylar cup (figure 25 is correct).

## Publication dates

The following publications are known to have been published later than the dates indicated on their cover.

*Phasmid Studies* volume 5 part 1 ("June 1996") was published on 8th July 1996.

*Le Monde des Phasmes* number 33 ("Mars 96") was published on 8th July 1996.

*Le Monde des Phasmes* number 34 ("Juin 96"), and number 35 ("Septembre 96") were both published on 4th November 1996.